Risk Factors for Upper Extremity Musculoskeletal Symptoms among Bovine Veterinarians

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ABSTRACT

Background

Bovine veterinarians experience an increased risk of reporting upper-limb musculoskeletal (MSK) symptoms when compared to the general population. One hypothesized cause is reproductive exams performed on cattle via rectal palpation, but this has not been conclusively verified via epidemiological study design or ergonomic assessment.

Objectives

This thesis answers the following research questions:

1) What self-reported individual and work-related risk factors are associated with work-preventing upper-extremity MSK symptoms in Western Canadian bovine practitioners?

2) Which physical ergonomic hazards (posture, repetition, force, and workplace design) are associated with bovine reproductive exams?

Methods

Multiple logistic regression analysis was performed on data from a cross-sectional survey of western Canadian bovine veterinarians to determine individual and workplace characteristics associated with work-preventing MSK symptoms in the past 12 months. Field ergonomic assessments were performed on seven bovine veterinarians at routine reproductive exam appointments on beef and dairy cattle. Posture, repetition, force, and workplace characteristics were assessed as potential ergonomic hazards.

Results

The final regression model retained three variables that predicted work-preventing upper-extremity MSK symptoms: height (continuous, OR 0.93 [0.87-0.99]), number of veterinarians in the practice (continuous, OR 1.32 [1.05-1.66]), and practice type (mixed animal vs. primarily bovine, OR 3.20 [0.96-10.64]). While annually estimated number of reproductive exams was not significant in the regression model, the field ergonomic assessment confirmed that during reproductive exam appointments veterinarians are exposed to awkward postures, repetitive movements, and forceful exertions both from the exams themselves and ancillary work-related tasks.

Conclusion

Bovine veterinarians are exposed to a variety of physical hazards that have been associated with upper limb MSK symptoms in other professions. Personal risk factors, such as height, number of co-workers, and practice type, may exacerbate the risk of developing these symptoms. It is imperative that prevention strategies be prioritized to ensure that bovine tasks become safer to ensure a healthy future for the bovine veterinary profession.

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Her name has already appeared in the previous paragraphs but my supervisor Dr. Catherine Trask made this experience of doing a Masters Degree truly outstanding. I feel so fortunate to have had such an exceptional, inspiring supervisor. You always set an amazing example for your trainees and employees. I am truly sad that our time together is already at an end! I learned so much from you.

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DEDICATION

This thesis is dedicated to my dad, who would have read the whole thing.

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LIST OF ABBREVIATIONS

BMI	Body mass index
CCHS	Canadian Community Health Survey
CCHSA	Canadian Centre for Health and Safety in Agriculture
CCOHS	Canadian Centre for Occupational Health and Safety
CTD	Cumulative trauma disorder
ISB	International Society of Biomechanics
MSD	Musculoskeletal disorder
MSK	Musculoskeletal
NIOSH	National Institute for Occupational Safety and Health
OR	Odds ratio
RSI	Repetitive strain injury
RULA	Rapid Upper Limb Assessment
SNQ	Standardized Nordic Questionnaire
US	United States
WCABP	Western Canadian Association of Bovine Practitioners
WCB	Workers' Compensation Board
WCVM	Western College of Veterinary Medicine

CHAPTER 1: INTRODUCTION

Bovine veterinarians in Western Canada experience high rates of self-reported musculoskeletal (MSK) symptoms (defined here as “ache, pain, or discomfort”), especially in the neck and shoulder, which interferes with work tasks in over 25% of practitioners[1]. While much research has been done to quantify the prevalence of this issue, investigations into the causes have yielded mixed results. Many of the job tasks performed by bovine practitioners hypothesized to increase the risk of MSK symptoms are specific to the profession and have not been studied in sufficient detail to propose effective interventions. In order to develop tailored prevention strategies, more information is needed to understand the specific physical hazards to which bovine veterinarians are exposed. This chapter will provide background on MSK symptoms in veterinarians, identify the research gaps, and state the objectives of this thesis. This thesis is part of the Ergo-Vet project (www.ergovet.ca) at the Canadian Centre for Health and Safety in Agriculture (CCHSA) Ergonomics Lab, which aims to assess and prevent musculoskeletal symptoms in bovine veterinarians.

1.1 Musculoskeletal Symptoms

There are several common terms that may be used in literature to describe musculoskeletal symptoms, including musculoskeletal disorders (MSD), cumulative trauma disorders (CTD), and repetitive strain injuries (RSI). From a clinical perspective, the terms “disorder” and “injury” are typically used to describe specific pathologies that have been diagnosed by a medical professional; as such they will only be used in this thesis if the cited study included the designation that the disorder or injury was clinically diagnosed. Otherwise, the term “musculoskeletal symptoms” will be used as an all-encompassing term, as many of the cited studies involve mainly self-reported symptoms.

1.2 Prevalence and Burden of Upper Extremity MSK Symptoms

Upper extremity MSK symptoms may be associated with muscles, nerves, tendons, and other structural tissues of the upper extremities. This includes the neck, shoulders, elbows, wrists, and hands[2]. Some specific examples of disorders that may be clinically diagnosed include carpal tunnel syndrome, thoracic outlet syndrome, and supraspinatus tendinitis[3].

It is difficult to know the true prevalence of these symptoms in the general population. The majority of publicly available injury statistics are typically generated through workers’ compensation boards (WCB). However, these data do not provide the complete picture of MSK symptoms in a population, as WCB usually do not represent self-employed workers, nor do they include disorders deemed to be non-work related, and they include only accepted claims, not self-reported symptoms. In Saskatchewan, for example, the WCB reports that there were 7,188 claims related to “bodily reaction and exertion” in 2017 (all employment sectors), but does not divide these claims by body region[4] and thus there are no published reports describing how many were related to upper extremity issues. In the academic literature, study scopes and MSK case definitions vary. For example, a 1998 article that calculated the Canadian economic burden of “musculoskeletal disorders” included conditions such as bone fractures and arthritis within its definition[5].

There is much research looking into upper extremity symptoms and disorders within specific occupations, but not so much at a national population level. The most recent published data attempting to specifically quantify upper extremity MSK symptom rates nation-wide in Canada is from the Canadian Community Health Survey (CCHS). In 2003, Statistics Canada produced a report on MSK symptom prevalence using the terminology “repetitive strain injury”; based on its 2000/1 CCHS survey results, 10% of Canadians aged 20 or over self-reported having a RSI that had limited normal activities in the past year, and just over half of these were reported to be work-related. The majority of reported RSI’s were related to the upper extremity; 25% of which affected the neck or shoulder[6]. In a French study from 2009, clinical exams were used to assess the prevalence of upper extremity MSD in a representative sample of the national working population, with 11% of men and 15% of women having at least one of the following at the time of examination: rotator cuff syndrome, lateral epicondylitis, ulnar tunnel syndrome, carpal tunnel syndrome, De Quervain’s disease, flexor-extensor peritendinitis; or tenosynovitis[7]. It is unusual that these rates of medically confirmed diagnoses are higher than the self-reported rates of the Canadian population, though the terminology used in the CCHS (“repetitive strain injury”) possibly discouraged respondents from reporting symptoms that they did not associate with a specific injury.

Multiple studies have been conducted into the economic costs of MSK symptoms and disorders. In general, the burden is costly, though it is difficult to compare between jurisdictions due to differing health care systems. In the United States in 2000, it was estimated that a third of every workers’ compensation dollar was due to MSD[8]. The Canadian Centre for Occupational Health and Safety (CCOHS) estimates that MSD are responsible for 25-60% of annual workers’ compensation costs across the country, and are the number one cause of lost work time[9]. As well as the direct health care and lost time costs, there are additional indirect costs, including negative impacts on quality of life, psychosocial effects, and loss of productivity due to presenteeism, i.e. attending work while injured or ill[10]. These indirect costs are especially important when considering MSK symptoms that are not considered injuries or disorders but are still a burden on the worker. A 2003 study found that 71% of health-related lost productive work time in the United States (absence plus unproductive time at work) was due to health-related unproductive time spent at work[11]. Although the portion of presenteeism due specifically to upper extremity MSK symptoms is unknown, one could surmise that this phenomenon impacts a relatively large proportion of the workforce given the high prevalence of workers' compensation claims for officially diagnosed MSK injuries.

While a variety of mechanisms and activities may contribute to the development of upper extremity MSK symptoms, a body of evidence has been growing over the past several decades that suggests work tasks may be a primary contributor.

1.3 Risk Factors and Hazards for MSK Symptoms

There are a number of ways to categorize risk factors for MSK symptoms to varying degrees of detail. In a large review of the epidemiologic evidence on workplace MSD and symptoms published by the National Institute for Occupational Safety and Health (NIOSH) in 1997, Bernard et al. separated physical or biomechanical risk factors for upper extremity MSK symptoms into four broad categories: repetition, force, posture, and vibration[2]. Within this thesis, physical risk factors will be primarily referred to as "hazards", which are defined by the CCOHS as a potential source of harm to a worker[12]. The term "risk factor" will be used to denote more inherent characteristics that still may increase MSK symptom likelihood but are not as easily modifiable by making changes to a workplace.

Repetition, force, awkward (non-neutral) posture, and vibration are considered to be physical hazards to which workers are exposed, in combination with individual risk factors (e.g. sex, age) and psychosocial risk factors[13], such as stress or mental fatigue. All three types of risk factors (physical, individual, and psychosocial) are important to consider but depending on the context, one risk factor may be easier to control than the others. This thesis will focus mainly on individual risk factors and physical hazards, thus the following literature review will focus on summarizing what is known about these topics with respect to the population under study: large animal veterinarians. A commentary on the interplay of psychosocial factors and recommendations for incorporating this risk factor into future research in this area appears in the Discussion (Chapter 4).

1.4 MSK Symptoms in Bovine Veterinarians

Several studies have investigated the occurrence of MSK symptoms and disorders in large animal veterinarians and other practitioners who work with animals. The first documented cases of MSD specifically in bovine practitioners were the subject of a case study published in the *Canadian Veterinary Journal* by Saskatchewan orthopedic surgeon Ronald Ailsby in 1996; the study postulated that rectal palpations (i.e. reproductive exams, see Figure 1-1) were to blame for a common cervical plexus injury in many of his patients who were bovine veterinarians[14]. Ailsby also presented a follow up paper at the American Association of Bovine Practitioners conference in 2009, expanding upon his initial work and describing the most common pathology as “chronic repetitive injury to the rotator cuff or brachioplexus,” attributed to “repetitive pregnancy checks” as well as acute trauma[15]. These appear, however, to be the only publications describing a defined pathology. The issue of MSK symptoms in veterinarians has been studied on a national scale in many countries, including Australia[16], New Zealand[17,18], the United States[19–22], the Netherlands[23], Ireland[24], Germany[25], Turkey[26], and recently in Western Canada as part of the “Ergo-Vet” project presented here[1]. All of the studies produce a consistent indication of a high prevalence of MSK symptoms occurring in veterinarians, as high as 96% (any musculoskeletal trouble in the past 12 months, all veterinarian types) in New Zealand[18]. The upper extremity, which includes the neck, arm, hand/wrist, upper back, and shoulder, is often cited as the most affected body region[1,18,20,25]. In particular, being a large animal veterinarian appears to be associated with the highest risk of MSK symptoms; analyses performed in Germany and New Zealand both found that large animal veterinarians reported higher rates of symptoms in nearly all body regions than small or mixed animal practitioners[18,25]. However to date, only three studies have focused specifically on MSK symptoms in bovine veterinarians[1,16,21].

While the body of literature on this topic is growing, the majority of articles are based on self-report surveys with low response rates, sometimes lower than 10%[24]. As well, no study appears to have resulted in a "second phase" where results were used to identify specific MSK risk factors and suggest prevention strategies. Thus, there is a clear need to further investigate this phenomenon with an overarching goal to go beyond previous studies and use the results to identify potential risk factors, perform ergonomic assessments, and suggest prevention strategies.

Prior to this thesis work, the Ergo-Vet project distributed surveys to Western Canadian Association of Bovine Practitioners (WCABP) members to investigate the prevalence of MSK symptoms in this population, how MSK symptoms affected their work and life, and what they perceived to be the most physically demanding work tasks. The survey results indicated that rectal palpations/pregnancy checking and other obstetric tasks (e.g. calving) were considered by the respondents to be the most physically demanding tasks. Nearly 90% of respondents reported experiencing musculoskeletal trouble (defined as "ache, pain, discomfort") in the past 12 months, with the most common body regions affected being the shoulder (63.9%), lower back (56.4%), and neck (51.1%). In the 12 months preceding the survey, 26.3% reported musculoskeletal symptoms interfering with regular work tasks, and 18.8% reported the symptoms interfering with bovine tasks specifically[1]. These numbers are much higher than the results from the previously mentioned Canadian Community Health Survey, which reported that 10% of Canadians had suffered an RSI that limited normal activities in the past year[6]. The Ergo-Vet survey also included open-ended questions which provided an opportunity for respondents to describe how musculoskeletal symptoms had interrupted their work, with responses provided by 97% of participants, and only 23 of 129 responses indicating no or minimal impact. A thematic analysis of 'work impact' responses encompassed six progressive themes: mild or no work-related symptoms, pain with no impairment, reduced productivity, temporary or permanent impairment, quality of life, and left (or would consider leaving) large animal practice[1]. It was very apparent from the survey responses that bovine veterinarians who are not impacted by MSK symptoms are few and far between.

1.5 MSK Symptom Risk Due to Bovine Reproductive Exams

The task of bovine reproductive exams (often referred to as rectal palpations, though this term implies a fully manual exam) is performed on average over 8,000 times per year by Western Canadian bovine veterinarians[1]. To confirm pregnancy status in a cow or heifer, a veterinarian must insert either their arm or an ultrasound probe into the rectum of the cow to either palpate or view the cow's reproductive organs and potential fetus (see Figure 1-1, or Figure 3-1). In some cases, such as for dairy cattle when information on the exact stage of pregnancy or reproductive cycle is required, the ultrasound probe must be manually held, such that the veterinarian still inserts their arm into the cow's rectum but does not palpate the organs. In other cases (mainly beef cattle, when only a "yes or no" pregnancy diagnosis is required), the ultrasound probe can be attached to a long extension wand which is inserted into the cow rather than the veterinarian's arm. Any version of the task may create exposure to the physical risk factors of awkward posture and high forces, potentially exacerbated by the repetitiveness of the task.

Figure 1-1: Veterinarian performing a manual reproductive exam (rectal palpation). Practitioner inserts entire arm into animal's rectum. The non-palpation arm may hold the animal's tail for support.

New Zealand veterinarians surveyed by Scuffham et al. identified rectal palpations as a task most likely (in their estimation) to lead to musculoskeletal symptoms, and cited the following perceived reasons, in descending order of frequency (including number and percentage of veterinarians that suggested the reason): repetitive activity (114, 25%), position and activity of upper limbs (77, 17%), frequency of procedures (45, 10%), awkward posture (41, 9%), and poor facilities/slip hazards (41, 9%)[17]. Repetition, frequency, and positioning of the upper limb were also suggested as musculoskeletal injury risks arising from rectal palpations by Ailsby in his 1996 Saskatchewan case study[14]. The presence of these risk factors is easy to confirm via conversations with practicing veterinarians and observations of the task. However, the epidemiological evidence is mixed, and only one study[20] thus far has shown a significant (though small) dose-response relationship between rectal palpations and self-reported MSK symptoms. A more thorough review of this relationship (or lack thereof) appears in the introduction section of Chapter 2, but it is sufficient to state that the existing evidence does not strongly support the hypothesis that reproductive exams cause MSK symptoms and disorders. This may change with a more thorough examination of the task, or a study designed to remove some of the limitations in the existing literature.

1.6 Theoretical Perspective

The conceptual framework for this thesis is an adapted model based on those by Armstrong, van der Beek & Frings-Dresen, and Winkel & Matthiasen[3,13,27]. The first two models frame a cyclical relationship between working capacity and the “dose” or internal exposure to physical risk factors[3,28]. Capacity is defined by Rodrick et al. as “the worker’s ability … to resist system destabilization resulting from various doses”[3]. The adapted model also borrows from Winkel & Matthiassen’s exposure-effect model which postulates that exposures and chronic effects are cyclically related, but may be modified at any point by individual and environmental (i.e. workplace design) factors[13]. For this specific project, the combined model (Figure 1-2) proposes an interactive relationship between the physical risk factors of posture, repetition, force and the veterinarian worker’s capacity. Work requirements and individual risk factors are shown to affect the worker’s exposure to physical risk factors. The relationship between the exposure to physical risk factors and working capacity predicts the worker’s likelihood of developing musculoskeletal discomfort or symptoms.

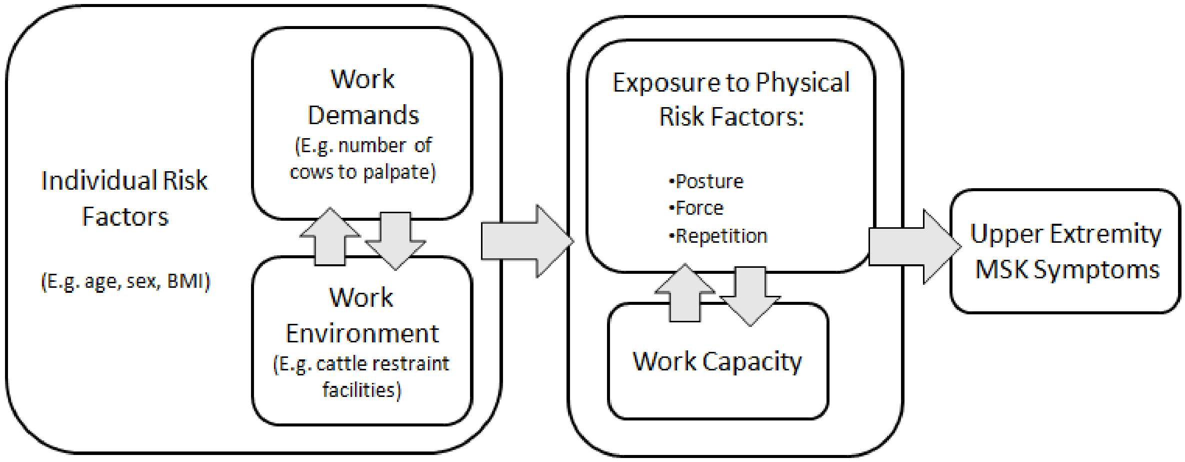


Figure 1-2: Adapted model for relationships between ergonomic risk factors, exposure, capacity, and pain. Customized for bovine veterinary work based on models by Armstrong, van der Beek & Frings-Dresen, and Winkel & Matthiassen [3,13,27]

While psychosocial risk factors are an important piece of an individual's exposure and have been shown to contribute to MSK symptoms and disorders[2], as previously mentioned they are outside the scope of the studies in this thesis but are discussed in Chapter 4.

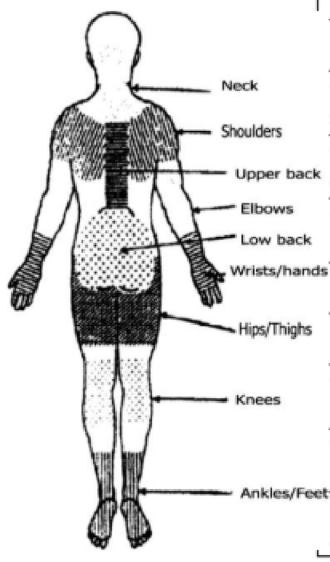
1.7 Assessment of MSK Risk Factors in Bovine Veterinarians

In general there are three potential methods to measure and quantify risk factors: self-report, observation, or direct measurement[13]. Each of these methods has strengths and limitations and should be selected to fit the study design and desired outcomes. For example, a direct measurement requiring a worker to stand on a force plate would provide an accurate estimate of the worker's balance parameters, but would not be feasible for a study with a large number of participants, or a study outside of a controlled laboratory setting.

For a study of cross-sectional design and a large number of participants spread over a variety of locations (which describes most of the literature on musculoskeletal symptoms in veterinarians), self-report has been commonly used. These studies have mostly focused on individual and workplace risk factors (e.g. anthropomorphic characteristics, number of coworkers) but many have required the participants to estimate their physical exposures to reproductive exams through various metrics, such as percent of workday spent palpating[20], average number of palpations per day[21], or average number of palpations per year[1]. However, this makes the assumption that reproductive exams are the task posing the most physical risk; while it has been established that veterinarians believe this to be true[1,17], there is currently no corroborating evidence to confirm it.

A methodology called the Standardized Nordic Questionnaire (SNQ) was developed in 1987 for standardizing self-reported MSK symptoms. Use of this questionnaire involves dividing the body into labeled regions and asking the respondent to indicate whether they have had any trouble (ache, pain, or discomfort) in the past 12 months in each region , and also any trouble in each region that prevented normal work at home or on the job[29]. This questionnaire has not been used consistently in the veterinarian studies, with a few exceptions[18,25]. The Ergo-Vet survey employed a modified version of the SNQ; the modification involved adding a third question regarding whether bovine work specifically had been prevented in the past 12 months[1]. The MSK symptom question from the Ergo-Vet survey can be seen in Figure 1-3.

25) This table is about your experience in the last *12 months*



	Have you at any time in the last *12 months* had trouble (ache, pain, discomfort) in:	Have you at any time in the last *12 months* been **prevented from doing your normal work** (at home or away from home) because of the trouble?	Have you at any time in the last *12 months* been **prevented from doing bovine tasks** because of the trouble?
Neck	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐
One or both shoulders	Yes [1]☑ No [2]☐	Yes [1]☐ No [2]☑	Yes [1]☐ No [2]☑
One or both elbows	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐
One or both Hands	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐
Upper Back	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐
Lower Back	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐
One or both hips/thighs	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐
One or both knees	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐
One or both ankles	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐

Figure 1-3: Ergo-Vet survey question utilizing modified SNQ to determine prevalence and impact of MSK symptoms[1]

The first manuscript in this thesis is a secondary analysis of the Ergo-Vet survey data and thus uses self-reported data to identify potential predictors of work-preventing musculoskeletal symptoms.

With a smaller number of participants, either observational or direct measurements may take place depending on the study design. In the case of this thesis' second manuscript, which is a field ergonomic assessment of reproductive exams performed by veterinarians, we employed a mix of observational and direct measurements. Posture and repetition were assessed observationally; a video recording of the veterinarian at work was taken and then played back in the laboratory to quantify repetition and time spent in non-neutral postures (i.e., hand above shoulder). Force to enter the cow was not measured directly, but estimated using a participant force matching protocol with a dynamometer while still at the field site.

In this thesis, all three measurement methods for quantifying individual and physical risk factors for veterinarians who perform reproductive exams were used. The resulting evidence provides the opportunity to portray this issue from a new perspective; it is hoped that will allow for effective prevention strategies to be developed and ensure that the profession of bovine veterinarians is a healthy one going forward.

1.8 Research Questions

This thesis will answer the following research questions:

1. What self-reported individual and work-related upper extremity MSK risk factors are associated with work-preventing MSK symptoms in Western Canadian bovine practitioners?
2. Which physical ergonomic hazards (posture, repetition, force, and workplace design) are associated with bovine reproductive exams?

The first manuscript (Chapter 2) answers Question 1 using previously collected survey data. The second manuscript (Chapter 3) answers Question 2 using a field-based ergonomic assessment.

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CHAPTER 2: MANUSCRIPT 1

Risk factors associated with work-preventing upper extremity symptoms in bovine veterinarians

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2.1 Abstract

Objective Large animal veterinarians around the world have reported high rates of upper-limb pain. One hypothesized cause is bovine rectal exams (palpations), but the evidence is equivocal. The aim of this study was to identify potential predictors of work-preventing upper extremity symptoms in bovine veterinarians working in Western Canada.

Design A cross-sectional survey was mailed to members of the Western Canadian Association of Bovine Practitioners. The survey included: a modified Standardized Nordic Questionnaire; information on personal and work characteristics; musculoskeletal (MSK) symptoms; and self-rated most physically demanding tasks.

Sample The survey response rate was 51% (133/262). 116 responses were included in this study, representing veterinarians who had performed rectal exams in the past 12 months, corresponding with any reported MSK symptoms.

Procedures Multiple logistic regression was performed on the survey data, using a dependent/outcome variable of upper-limb symptoms that prevented the veterinarian from doing normal work in the past 12 months. Independent variables focused on personal and work characteristics. Hosmer-Lemeshow goodness-of-fit and significance ($p<0.05$) testing were used to select the final model.

Results Veterinarian height (OR 0.93 [0.87-0.99]), number of veterinarians in the practice (OR 1.32 [1.05-1.66]), and practice type (mixed animal vs. primarily bovine, OR 3.20 [0.96-10.64]) were predictors of reporting work-preventing symptoms. Rectal exams were not a significant predictor ($p=0.13$).

Conclusion and Clinical Relevance The number of rectal exams was not found to be a significant predictor of work-preventing upper extremity symptoms in this cross-sectional

sample. Prevention efforts should consider practice characteristics as well as practitioners' personal characteristics.

2.2 Introduction

Over the past few decades, a number of studies have reported on the occurrence of musculoskeletal (MSK) symptoms in veterinarians, with a special interest in practitioners that work with cattle. MSK symptoms may be referred to in the literature as cumulative trauma disorders, repetitive strain injuries, or work related musculoskeletal disorders; here we define it as "ache, pain, or discomfort in muscles, bones, or tissues". The first reported hypothesis of a cause was published in the *Canadian Veterinary Journal* in 1996 by Dr. Ronald Ailsby, a Canadian orthopaedic surgeon, who deduced from treating a number of cattle veterinarians with shoulder and neck pain that performing rectal examinations on large animals was associated with injury to the cervical plexus[1]. Veterinarian injuries and MSK symptoms have been studied epidemiologically in the United States[2–6] Australia[7], New Zealand[8,9], Europe[10–12], and more recently in Turkey[13] and Western Canada[14,15], though only three studies (Cattell[2], Lucas et al.[7], and Zeng et al.[14]) have focused specifically on cattle veterinarians. While the scope of these studies varies, a common finding is a consistent indication of a high prevalence of MSK symptoms occurring in large animal veterinarians, ranging from a lifetime prevalence of 47-71% in the US[2,4,6] to as high as 100% in the past 12 months (any MSK trouble, CI 96-100%) in one New Zealand study[8]. It is common in most studies for the upper extremity (including the neck) to be named as the most or second most affected body part[4,6,8,11].

The task of bovine rectal exams (or palpations, if done manually) is performed on average over 8,000 times per year by Western Canadian bovine practitioners[14], generally in the fall/early winter for beef cattle and year-round for dairy. It is done primarily for confirming pregnancy status, and can be executed one of three ways: via manual palpation, manually inserting an ultrasound probe into the rectum, or using an ultrasound extender wand which eliminates the need for the veterinarian to insert their arm into the animal. All versions of this task, including extender wand use, expose practitioners to ergonomic hazards (repetitive and forceful non-neutral postures), as was determined in a comparison of manual and wand exams using the Rapid Upper Limb Assessment (RULA) method[15]. When the exam is manual, the veterinarian is potentially exposed to high forces required to push their arm into the animal as well as stabilizing their body against the movements of the animal[15]. Awkward (non-neutral) posture, high force, and repetition are known contributors to musculoskeletal injuries[16,17].

A few studies have specifically attempted to verify Ailsby's hypothesis and link upper-extremity MSK symptoms to rectal examinations. When veterinarians are asked to identify tasks that might cause MSK symptoms, rectal exams consistently emerge as a top hypothesized contributor[6,9,13]. A recent survey from Utah found that 93% (40 of 43) of respondent veterinarians who perform frequent palpations experienced pain or injury that they attributed to palpating[18]. However, when modeled to investigate associations, results are mixed. Scuffham et al. found evidence that self-reported number of rectal palpations per year may be associated with work-preventing (self-reported) MSK symptoms, though a consistent dose-response relationship was not established[8]. Lucas et al. found that obstetric procedures, including rectal exams, accounted for the majority of serious (resulting in hospitalization or work-prevention) injuries to Australian bovine veterinarians, though only 17% of rectal exam-related injuries were attributed to overexertion or strain[7]. Cattell's survey of American Association of Bovine Practitioners members found that while upper extremity MSK symptoms were more likely to occur on the side of the body used for palpating, the amount of exposure did not predict the likelihood of reporting musculoskeletal symptoms, and severity of symptoms was not reported[2]. Kozak et al. reported a small but non-significant increased odds relating self-reported work-preventing symptoms in the hand/wrist and elbow to rectal palpations for German veterinarians[11]. Only one study, conducted by Berry et al. on California veterinarians, appears to show a significant small dose-response relationship between self-reported time dedicated to rectal exams and (self-reported) MSK symptoms (increased odds of 1.02 (CI 1.01-1.03) per percent of work time spent palpating)[6].

A recent descriptive analysis published by our team focused on Western Canadian bovine veterinarians[14]. This study quantified the prevalence of MSK symptoms or “trouble” (defined as “ache, pain, or discomfort”) among Western Canadian bovine practitioners, described its impact on veterinary work, and identified the most physically demanding tasks to be studied in future phases of the project. Nearly 90% of respondents reported experiencing MSK symptoms in the past 12 months, with the most common body regions affected being the shoulder (63.9%), lower back (56.4%), and neck (51.1%). Furthermore, 26.3% reported MSK symptoms (any body region) interfering with regular work tasks in the 12 months preceding the survey. The survey results indicated that bovine rectal exams were considered by the respondents to be one of the top three most physically demanding tasks they engage in at work[14]. A secondary analysis of this data looked into potential predictors of shoulder symptoms, and found that veterinarians who were female, less experienced, worked in larger practices, and engaged primarily in mixed animal work had increased odds of experiencing shoulder symptoms[15].

Existing literature appears to suggest that performing rectal exams may be associated with both general and work-preventing MSK symptoms, but the evidence for this is limited and inconclusive, with only one example of a dose-response relationship emerging thus far, and all studies use self-reported data only. The aim of this study was to identify self-reported individual and work-related risk factors that are associated with work-preventing upper extremity MSK symptoms in Western Canadian bovine veterinarians. We also hypothesized that the cumulative load related to rectal exams would emerge as a significant predictor in our model.

2.3 Materials and Methods

2.3.1 Recruitment and data collection

The methods for the survey data used in this study have been reported in detail in Zeng et al.'s descriptive analysis[14] of the prevalence and impact of musculoskeletal symptoms on Western Canadian bovine veterinarains. In brief, 262 current members of the Western Canadian Association of Bovine Practitioners (WCABP), both practicing and retired, were invited to be participants in this study. Data was collected between March and August, 2017. Surveys were initially mailed to potential participants via the WCABP quarterly newsletter. Three targeted mailings of the survey to addresses provided by the WCABP were conducted using the Dillman method[19]. Participation was completely voluntary. The study was approved by the University of Saskatchewan Biomedical Ethics Board.

2.3.2 Study & Survey design

The study design was cross-sectional and the survey focused on the last 12 months, consisting of 25 questions on personal characteristics (anthropometry, sex, upper limb dominance), work experiences and tasks, and general MSK health. Participants were asked to estimate the number of bovine rectal exams they performed per year and the percentage of practice time apportioned to dairy, beef, equine, other large animals, and small animals. An adapted Standardized Nordic Questionnaire[20] (SNQ) was used to indicate specific body region(s) where MSK symptoms/trouble (defined as "ache, pain, discomfort") was experienced during the past 12 months. The options were neck, shoulders, upper back, elbows, wrist/hands, lower back, hips/thighs, knees, and ankles/feet. Three potential outcomes corresponding to each possible body region were included: *"Have you at any time in the last 12 months had trouble (ache, pain, discomfort)?"*, *"Have you at any time in the last 12 months been prevented from doing your normal work (at home or away from home) because of the trouble?"*, and a novel question *"Have you at any time in the last 12 months been prevented from doing bovine tasks because of the trouble?"*

2.3.3 Variable definition

The outcome (dependent) variable for this specific analysis was having been prevented from doing normal *or* bovine work in the last 12 months due to *any* upper limb (neck, shoulders, upper back, elbows, wrist/hands) trouble. This combination was necessary due to the relatively low number of participants who reported having work interruption from a single body region, and combining the upper limb is appropriate as common injuries to the upper limb may have referral patterns that include many or all of the listed areas[21–23].

Several new variables were calculated based on raw data from the survey. Number of manual palpations performed per year, and ultrasound wand assisted exams, were calculated based on participants' responses to the survey questions *"Indicate the average number of rectal examinations you perform per year"* and *"If you use ultrasound, what percentage of time do you use an extension (handle extender)?"* Both of these variables were split into three categories: zero, greater than the median, or less than the median. Based on the number of rectal exams reported for beef and dairy, we calculated a categorical variable representing the primary cattle type with which the veterinarian worked. We created a new variable, "palpation arm," to investigate whether palpating with one's dominant or non-dominant side had any effect on symptoms.

2.3.4 Statistical analysis

Logistic regression was conducted using SPSS version 25.0[a]. A purposeful selection of covariates model building strategy, as described by Hosmer, Lemeshow, and Sturdivant[24] was used; bivariate analyses using simple logistic regression were performed for each potential independent variable and variables with a threshold p-value <0.25 were considered for inclusion in the final multiple logistic regression model. Variables were a mix of continuous and categorical (see Table 2-1 for complete list); variables that were originally continuous but not significant were then categorized to check for improved significance. If no improvement emerged the continuous version of the variable was used. Multicollinearity was assessed using Spearman correlation coefficients; when variable pairs had a correlation coefficient $\rho>0.5$ the variable that better represented the working population was offered to the final model. The final model retained those variables that were either significant ($p<0.05$) or improved the fit of the overall model, with the Hosmer-Lemeshow test being used to select the best fit model. Potential interactions between all variables in the final model were tested using the likelihood ratio test. Independent variables from the final model and those originally offered to the final model were also checked for confounding status by comparing adjusted and crude odds ratios (OR) for the primary risk factor, with a cutoff of 15%. OR and 95% confidence intervals (CI) were calculated for each variable in the final model to describe the strength of the association.

Because we were expecting to see an association between work-interrupting MSK symptoms and rectal exams, the number of exams per year (either manually, ultrasound-assisted, or total – whichever emerged as most significant) was initially considered to be the primary risk factor in the regression model.

2.4 Results

Out of 262 potential participants, the survey sample size was n=133 which corresponded to a response rate of 51%. The data set of 133 respondents was cleaned to remove retired members and/or those who had stated in their responses that they had not performed rectal exams in the past year and instead had provided their career average. This yielded a final sample size of 116 veterinarians who had performed rectal exams in the last 12 months, the timeline corresponding with their reported MSK symptoms.

Results of the bivariate analysis are presented in Table 2-1, along with the characteristics of the study respondents and number of respondents who reported having been prevented from doing regular or bovine work in the last 12 months due to upper limb trouble. Several personal characteristics (age, sex, height, BMI, and palpation arm) had a p-value below 0.25 and were offered as candidates for the final model. Work characteristics offered to the final model were "practice type" (>50% cattle vs. mixed animal), "total rectal exams (ultrasound and manual combined) per year", "years of experience", and number of other veterinarians in the practice ("veterinarian colleagues").

The variables sex and height showed a strong correlation (Spearman $\rho>0.6$), thus only height was offered to the final model as it had a narrower confidence interval.

Table 2-1: Bivariate Analysis of Candidate Variables with Work-Preventing Upper Extremity MSK Trouble in Past 12 Months

Variable	Number of Responses	Missing Responses	Work Prevention	Unadjusted OR (95% CI)	p-value
Age*	115	1	18	0.97 (0.92-1.01)	0.12
Sex		1			
Male	83		7	1	
Female	32		11	5.69 (1.96-16.48)	<0.01
Height†	116	0	18	0.92 (0.87-0.98)	<0.01
Palpation arm		0			
Non-dominant side	67		8	1	
Dominant side	49		10	1.89 (0.69-5.21)	0.22
BMI		1			
Normal	40		8	1	
Overweight	49		5	0.46 (0.14-1.52)	0.20
Obese	26		5	0.95 (0.27-3.31)	0.94
Perception of Overall Health		0			
Excellent	34		4	1	
Very Good	60		9	1.32 (0.38-4.67)	0.66
Good or Fair	22		5	2.21 (0.52-9.34)	0.28
Poor	0			n/a	n/a
Years of Experience‡	116	0	18	0.96 (0.92-1.01)	0.10
Veterinary Colleagues§	113	3	17	1.19 (0.98-1.45)	0.08
Average Rectal Exams per Year||		0			
<8 950	58		12	1	
>=8 950	58		6	0.44 (0.15-1.27)	0.13
Practice Type		0			
>50% Bovine	78		8	1	
Mixed	38		10	3.13 (1.12-8.73)	0.03
Cow type		1			
Primarily beef	82		13	1	
Primarily dairy	33		5	0.95 (0.31-2.91)	0.93

*Continuous, increments by year
†Continuous, increments by cm
‡Continuous, increments by year
§Continuous, increments by colleague
||Combined manual and ultrasound wand

The final multivariable model is shown in Table 2-2 (Hosmer-Lemeshow test p=0.850). The hypothesized primary risk factor, "total rectal exams per year", did not contribute to the final model, either significantly, as an improvement of fit, or as a confounder. Thus, the variable "practice type" can be considered the primary risk factor in the final model. The continuous variable of height had a protective effect on the outcome; as height increased, the participant's odds of reporting work prevention decreased. As the number of veterinarian colleagues increased, so did the odds of reporting work prevention due to upper limb trouble. The odds of reporting work prevention increased over three times for mixed practice veterinarians in comparison to those who attributed most of their practice time to cattle.

Table 2-2: Final Multivariable Model

Variable	Adjusted OR (95% CI)	p-value
Practice Type		
>50% Bovine	1	
Mixed	3.20 (0.96-10.67)	0.06
Height	0.93 (0.87-0.99)	0.04
Veterinary Colleagues	1.32 (1.05-1.66)	0.02

No significant interactions between variables were observed. Height and number of veterinarian colleagues were both found to confound the primary risk factor by over 30%, though in opposite directions – height confounded practice type by 41% away from null, and number of colleagues confounded it 31% towards the null. No confounders outside of the variables in the final model were observed, including age or years of experience.

2.5 Discussion

The primary risk factor in our final model was "practice type", and we found that veterinarians who engage in mixed practice had over three times the odds of self-reported work-preventing upper extremity symptoms as their colleagues who devoted over 50% of practice time to cattle. This was opposite to what was expected and has previously been reported in other studies[3,4,8], and may point to a healthy worker effect in our specific population, which is different from the majority of other research as our sample did not include any veterinarians who work exclusively with small animals. The descriptive study by Zeng et al. reported that many veterinarians described cutting back on large animal work and diversifying more into mixed practice due to MSK trouble[14]. It is possible that veterinarians who perform primarily bovine work late into their careers are able to stay healthy enough to do so, and those who experience MSK trouble subsequently reduce their large animal work. Another explanation for this potential healthy worker effect could be that as veterinarians gain more experience, they learn adaptations for performing physically demanding tasks to reduce their risk of injury. Regardless of the pathway, this result was similar to our analysis of the current survey data focusing solely on shoulder trouble in the past 12 months; we found that mixed animal veterinarians had an OR of 2.83 (1.01-7.93) of experiencing shoulder trouble compared to primarily bovine veterinarians[15].

As veterinarians' height increased, their odds of reporting work-preventing symptoms decreased. This makes sense as bovine work is highly physical, and would take a higher toll on smaller-statured individuals who may also have less physical strength. The task of rectal exams specifically would also require a higher reach for shorter veterinarians; any upper arm flexion or abduction greater than 60° is defined by the Center for Disease Control's National Institute for Occupational Safety and Health (NIOSH) as an "awkward posture" and has been shown to be associated with shoulder disorders[17]. Although height was highly correlated with sex, it was selected to remain in the model as it contributed to a slightly better fit model and encompassed the range of sizes of all study participants. However, it is possible that in actuality, sex rather than height could be the potential explanation, as women do experience higher rates of MSD than men, even when performing identical tasks[25]. Female veterinarians in western Canada are also more likely to work part time than male veterinarians[26], and part-time workers may have more natural flexibility to take time off for injuries or MSK pain, which may manifest in higher reporting of "work prevention". Our study sample included a limited number (32, 28%) of women; had we a greater proportion of female participants it is possible sex would have emerged as a stronger predictor.

As number of veterinarian colleagues within a practice increased, so did the odds of upper extremity symptoms preventing work. This is not necessarily surprising; if a veterinarian has others with whom they can share the workload, it may be more feasible to take time off work to recover or rest from MSK symptoms. Conversely, veterinarians working in smaller practices in rural areas where it is difficult to access veterinary services may feel pressured to continue working even if experiencing MSK symptoms. The possible explanation for this variable as a risk factor is nuanced and should not be simply interpreted as "working in a larger practice leads to symptoms", but rather that veterinarians in larger practices may miss work more than those working in smaller practices. This is likely related to work support and not a difference in injury potential.

The initial hypothesized primary risk factor, annual number of rectal exams (either via ultrasound extender, manually, or in total) was not found to be significant in the final model and was not included. This is consistent with the findings of Cattell and Scuffham et al.; veterinarians who perform rectal exams do have increased MSK symptoms but no dose-response relationship was present[2,8]. Conversely, Berry et al. found California veterinarians had increased MSK symptoms with increased palpation frequency; however, the bovine veterinarians in this study were mainly dairy practitioners[6] and thus the sample was likely more homogeneous in terms of rectal exam requirements and conditions (e.g. an ultrasound extender is not used on dairy cattle). We included both beef and dairy veterinarians, similar to that of Cattell. We modeled exposure in multiple ways to attempt to find a relationship (continuous normalized, continuous percentage, categorical) between overall number of exams as well as ultrasound *versus* manual, but none of these were significant. It may also be important to note that the number of rectal exams performed by veterinarians in our study is very different from the existing literature. The median value for Western Canadian bovine veterinarians was 8,950 exams/year (range 5-80.190); veterinarians in the German study reported performing maximum 2,400 exams/year[11] and the majority of New Zealand veterinarians performed less than 2,401 exams/year[8]. Berry's California study measured exposure to rectal exams in a different way, as percentage of work time spent palpating[6], rather than actual number of palpations performed. Interpretation is less clear for Cattell's study, which reported an average of 365 palpations/day[2] for American bovine veterinarians. This translates to over 95 000 palpations/year for a 261 work-day year, which seems highly unlikely for the average bovine veterinarian. Given the range and reliability of reported exposures, a meaningful comparison of our data to other studies in this area may not be possible. The existing evidence suggests that cumulative exposure could be less important than the exposure itself, i.e. any exposure to the ergonomic hazards present in rectal exams may put the veterinarian at risk of MSK symptoms. However, this would need to be confirmed via longitudinal study designs. To date, no prospective study has been conducted to investigate this potential relationship, with the majority of the studies being of cross-sectional design and not exclusively conducted on large animal veterinarians.

Age is often a significant predictor of upper-extremity MSK symptoms[17], but it was not found to be in this study. It was highly correlated with years of experience, but neither variable contributed to an improved fit of the model. Both variables were also ruled out as possible confounders. If there is in fact a healthy worker effect in this study population, or improved adaptations to the job with experience, we would not expect to see age and experience variables emerge as predictors.

These results should be considered in light of many study limitations. The survey design was cross-sectional and symptoms do not account for anything beyond the past year; in narrative responses many participants described debilitating injuries that they had overcome in the past[14] that were not accounted for in our survey results. The time of year the data was collected may have contributed to a recall bias; beef veterinarians would not have been performing any palpations during the collection period and thus may have not had a clear memory of their symptoms during the past palpation season. We were limited by the survey data; there are likely other variables that could have provided more context for the final model, such as whether a veterinarian worked full or part-time. The final sample size of n=116 was quite small and thus there is the possibility of a Type II error in our results, especially with only 18 respondents who reported having work-preventing upper extremity symptoms. The low number of respondents with work-preventing symptoms may not be reflective of the actual number, as there could be multiple interpretations of the question. For example, some may interpret "prevention" as needing to completely miss work, while others might interpret it as having to reduce participation in certain tasks, and this was not defined in the survey. In Zeng et al.'s descriptive study, 97% of participants provided written descriptions of how MSK trouble had negatively impacted their work or life, but only 26% reported it on the modified SNQ section of the survey[14]. There is likely a better way to conceptualize the cumulative biomechanical impact of repeated rectal palpations on MSK symptoms that no one has yet identified. For example, for beef veterinarians (71% of our sample) this task is highly seasonal, while dairy veterinarians spread it over a full year; many of our survey participants described taking extended recovery periods during the summer before pregnancy check season began. Ailsby also described the positive effect seasonal recovery periods had on his patients[1]. Tracking exposure and symptoms on a monthly basis over a year with a longitudinal study design would likely be a more effective way to measure the possible seasonal impact of exposure on symptoms.

Despite the limitations, the results in the current study's final model are troubling since they describe almost perfectly the demographics of current graduating classes and the predominant practice types of new veterinarians in North America. A study including data from 2008-2013 found that 80% of Canadian veterinary graduates were female[27] and thus shorter statured (American women are on average over 5 inches shorter than American men[28]). This was the same percentage of female veterinary students attending American veterinary schools in 2017[29]. This trend appears to be holding; the Western College of Veterinary Medicine at the University of Saskatchewan only admitted 14 male students in the 2018/19 academic year, in a class of 78 total students[30]. According to a 2014 survey of western Canadian veterinarians, women made up only 23% of food animal practitioners, and single-vet practices were in decline[26]. This trend is similar to the state of veterinary practice in the United States; a report on veterinary market trends between 1990-2010 found that female veterinarians were less likely to be food animal practitioners, and both male and female veterinarians are trending away from rural work[31]. Thus, our finding that smaller-statured veterinarians who work in mixed practice with multiple colleagues are more likely to have work-preventing MSK symptoms speaks to the potential for a looming sustainability challenge in rural North American large animal veterinary services.

This study expanded on previously published results[14,15] to investigate predictors of work-preventing upper extremity MSK symptoms in bovine veterinarians. Predictors were a mix of individual and work-related characteristics, and the results display a clear and immediate need for prevention research in this area. The present study appears to be one of only three published projects that specifically focused on bovine veterinarians[2,7], and is the only one to employ the Standardized Nordic Questionnaire and perform a multiple logistic regression analysis.

The existing research highlights a problem to be solved, and the solution is not likely to be found in survey data. Researchers will need to engage with bovine veterinarians in the field to measure and identify the potential contributors to MSK symptoms that arise during routine veterinary work. This research should not only focus on biomechanical contributors, but also consider organizational and psychosocial workplace factors, which the present study suggests may be as or more important than the physical workload. When the risk factors are understood, we can begin to develop prevention strategies in order to foster career longevity in this increasingly diverse practitioner group.

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2.8 Footnotes

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CHAPTER 3: MANUSCRIPT 2

Ergonomic Assessment of Veterinarians Conducting Bovine Reproductive Examinations

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3.1 Highlights

- First published ergonomic assessment of bovine reproductive exams involving multiple participants
- Bovine reproductive exams are hypothesized to cause veterinarian musculoskeletal injuries
- Confirmed this task exposes veterinarians to awkward postures, repetition, and high forces
- Veterinarians also routinely participate in other hazardous tasks at bovine appointments

3.2 Abstract

Large animal veterinarians experience high rates of musculoskeletal (MSK) symptoms, especially in the upper limb. Much survey-based epidemiological research has been carried out to determine whether bovine reproductive exams are the cause, but results have been mixed. We performed a field-based ergonomic assessment of seven bovine veterinarians performing reproductive exams on beef and dairy cattle over 14 appointments. Posture, repetitive movements, and workplace design/organization were assessed observationally via video playback. Force to conduct a rectal palpation was estimated in the field using a force-matching protocol. Veterinarians were confirmed to be engaging in postures, repetitions, and forceful exertions that have been associated with MSK symptoms in other professions. These physically hazardous behaviours were observed both during reproductive exams as well as performing other tasks not inherent to the exams, such as opening gates and participating in cattle handling. Prevention strategies should prioritize minimizing exposures during secondary hazardous tasks.

3.3 Keywords

Musculoskeletal disorder, awkward posture, force, repetition, field study, upper limb

3.4 Introduction

Musculoskeletal (MSK) symptoms in large animal veterinarians and their potential predictors have been studied in a variety of countries, with consistently high prevalence of upper-limb symptoms found in this population[1–4]. It has long been hypothesized that for veterinarians who work with cattle, reproductive exams are a major contributor to MSK pain and injury[5–7]. This task involves inserting either one's arm (rectal palpation) or an ultrasound wand into the rectum of a cow to check the reproductive or pregnancy status (Figure 3-1). Rectal palpations cannot be completely eliminated via technology, though in beef cattle an ultrasound extender wand can often be used for the majority of reproductive exams, with manual palpations only necessary for occasional confirmations.

Figure 3-1: Ultrasound Wand (left) and Rectal Palpation (right) for Reproductive Exams

Epidemiological evidence on the association between MSK symptoms and bovine reproductive exams is mixed. One issue is that the majority of studies are of cross-sectional design[2,3,6–8], which cannot establish cause and effect relationships. Most studies also use self-reported data and there is a lack of consistency in the metrics used for quantifying symptoms and the total exposure burden of exams. Further complicating this issue is that the task may be seasonal based on the type of cattle; dairy cattle are commonly palpated year round while beef cattle are generally only examined in the fall and often using an ultrasound wand.

Despite the lack of consistent evidence, veterinarians perceive reproductive exams to be one of the top tasks that causes their upper-limb symptoms[2,9,10]. In Western Canada, bovine veterinarians rated reproductive exams as the second most physically demanding task they perform[4]. In a large New Zealand survey of veterinarians of all practice types (small, large, and mixed animal), rectal palpations also emerged as a top perceived cause of MSK symptoms[11]. Lucas et al. found that for Australian cattle veterinarians, 75% of injuries resulting in hospitalization, lost time, or prevented normal work for at least five days occurred while performing obstetric procedures, the most common of which was pregnancy checking[12]. Aside from the risk of acute injury from working in close proximity to an unpredictable large animal, these exams can introduce repetitive movements and forceful awkward postures to an already hazardous task, as was found in an analysis using Rapid Upper Limb Assessment (RULA) of manual and ultrasound-wand assisted exams under optimal conditions[13]. Workplace exposures to repetition, forceful/heavy physical work, and awkward (non-neutral) postures have been shown to be associated with MSK symptoms in the upper limb and lower back in large-scale systematic reviews[14,15].

Aside from the above-mentioned RULA analysis, no published ergonomic assessment for this task could be found; the closest being a clinical report of shoulder injuries in bovine veterinarians by an orthopaedic surgeon, published in the *Canadian Veterinary Journal* in 1996. The surgeon performed a survey of large animal veterinarians asking about rectal palpations and symptoms and diagnoses, and suggested both a hypothesis for a likely pathology and prevention strategies[5], but that assessment and results were based on an assumed pathology, which is less useful to an ergonomics practitioner or worker without a clinical diagnosis whose goal is to prevent injuries before they occur. The objective of the present study was to quantify potential ergonomic hazards (posture, repetition, force, and workplace design/organization) during routine bovine reproductive exam appointments so that prevention strategies can be prioritized and developed.

3.5 Materials and Methods

3.5.1 Participants

A study recruitment email was initially sent to members of the Western Canadian Association of Bovine Practitioners (WCABP) residing in a 90km radius of the research university in summer 2018 by WCABP administrative staff. Two follow-up emails were sent in September and November 2018, the latter which expanded the recruitment pool to the entire province of Saskatchewan. Snowballing was also used to access the professional networks of our veterinarian authors to directly contact potential participants. In total, three of seven participants were recruited via the WCABP email list, with the remainder recruited through direct invitation.

All participants provided written informed consent to participate in the study. The study was approved by the University of Saskatchewan's Behavioural Ethics Board.

Researchers accompanied each participant on two routine reproductive exam appointments between October 2018 and January 2019 inclusive. Participants performed both manual palpations and ultrasound wand assisted exams, and farm/cattle type varied between appointments. Participants completed a survey regarding personal and workplace characteristics, current and past MSK symptoms, and perceptions of physically demanding tasks, using questions from a previously published descriptive analysis of MSK discomfort among Canadian veterinarians[4].

3.5.2 Video observation

Each appointment was video recorded by the researchers, to later use the playback to analyze three main variables: repetition/frequency of exams, veterinarian posture and physical activity, and working environment.

Repetition and frequency was assessed by determining the following for each appointment via video playback: number of exams performed, duration of each exam (in seconds), and time elapsed between each exam (in seconds). From these values, the median exam time, median rest time, and percentage of observed time spent performing exams was calculated. The percentage of appointment spent performing exams was calculated by dividing the total exam time (sum of all observed exams) by the observed time.

Posture and physical activity were assessed by observation. Observers watched for arm inclination of at least 60°. This was assigned to each participant as an “average” posture per collection occurring during the majority of exams rather than for each cow. Other routine physical activities (e.g. cattle handling, operation of cattle restraint facilities) that exposed the veterinarian to awkward postures were recorded for each veterinarian.

Workplace design and organization were observed for the creation of additional ergonomic hazards and exposures to the veterinarian while they performed reproductive exams and associated activities. These included: exam type (ultrasound wand or manual palpation), cattle restraint system/facilities (see Figure 3-2 and Figure 3-3 for descriptions of typical restraint facilities), and movement of the cattle. Cattle agitation (an agitated cow defined as subjecting the veterinarian to sudden, forceful movements while being examined) was assessed on a scale of 1-3: 1 being the majority of cattle during the visit were not agitated, 2 as approximately half of cows were agitated and half were not, and 3 as the majority of cows appeared agitated.

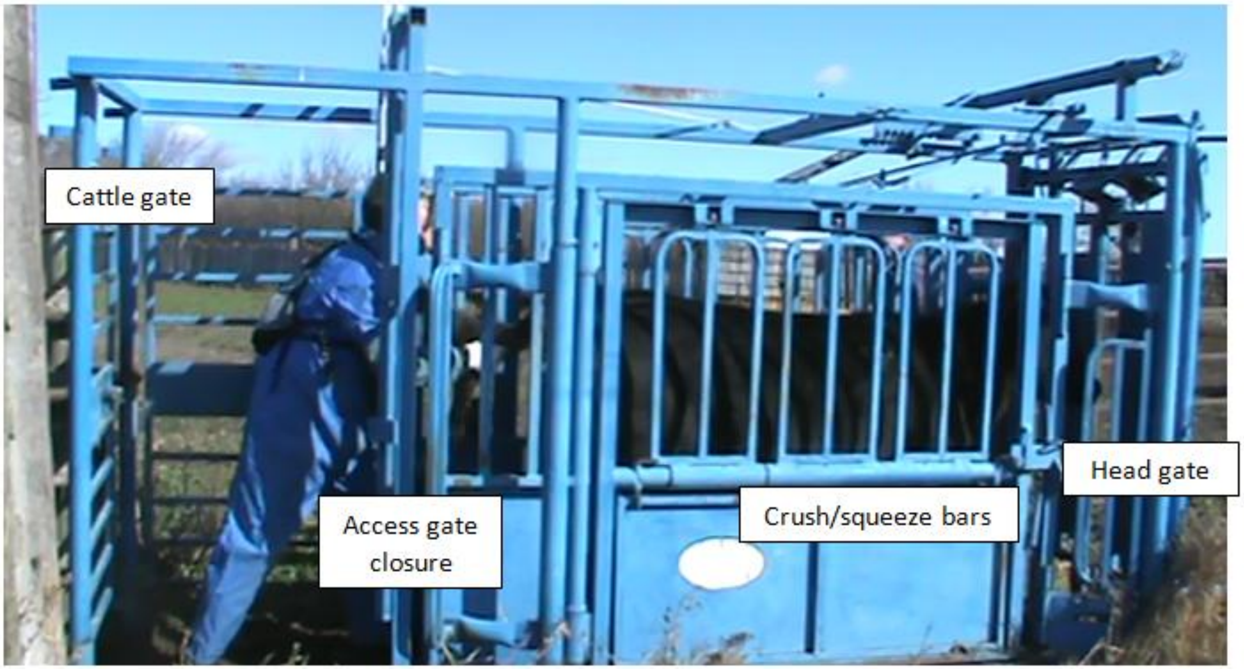

Figure 3-2: Typical restraint facilities for beef (crush chute). May also be called a "cattle squeeze", as bars should pull in to squeeze the cow's sides to restrain its movement and calm the animal. Cow enters the chute through the cattle gate while the access gate is closed. When cow is secured in the crush (usually by another worker operating the head gate), the veterinarian enters through the access gate to palpate behind the cow.

Figure 3-3: Veterinarian palpating dairy cows in head lockers. Cattle heads are secured through locked bars (similar to crush chute head gate) so they cannot move backwards, but may move around from side to side.

3.5.3 Entry force estimation

As it was not practical to directly measure the force used by the veterinarian to either push their arm or the ultrasound wand into the cow's rectum, a force matching estimation protocol was used. Adapting protocols from Bao and Silverstein[16] to accommodate a flat-palm posture, veterinarians were asked to assume a posture similar to their exam posture. Ten cows were chosen at random during the appointment and the distance between the floor and the rectum was recorded and averaged. The veterinarian was asked to push with their palpation arm on a microFET®2 Handheld Dynamometer with the average amount of force used to enter the cattle, on a static vertical surface at rectum height of the average cow. This was repeated five times and used to calculate the average estimated force.

3.6 Results

3.6.1 Participant demographics

Seven veterinarians completed the full study, and each was followed on two different appointments.

The physical and work characteristics of the participants can be found in Table 3-1. The participants represented a wide range of experience and work situations. All but two participants (one abstained from answering) reported having upper limb symptoms in the past 12 months, but none reported these symptoms interfering with their work.

Table 3-1: Participant demographics

Participant	Age	Years of Experience	Sex	Height (cm)	% Practice as Bovine Work	Exams per Year	Any Upper Limb Symptoms in Past 12 Months
1	30	5	F	163	65	3,000	Yes
2	37	10	M	178	45	7,000	Yes
3	34	9	M	178	80	16,000	Yes
4	60	32	M	169	95	10,000	No
5	47	22	M	175	60	11,000	Yes
6	37	13	F	173	45	6,000	Yes
7	66	41	M	185	75	2,000	declined to answer

3.6.2 Repetition

The number and duration of exams recorded from video are listed in Table 3-2. Median exam and rest time were calculated instead of means. For rest time especially, the distribution was skewed as there were several contributors to sporadic "longer" rest periods such as traveling from one barn to another, bringing new groups of cows in from a secondary holding pen, or waiting for other farm tasks to be completed (e.g. milking), such that mean rest time between exams was not an appropriate metric. Veterinarians exceeded 100 exams/hour during three collections.

Table 3-2: Observed task durations and characteristics for bovine veterinarians during farm-based reproductive exam appointments

Vet	Visit	Total Observed Time (h:m:s)	Total # of Exams	Exams / hr	Median Exam Time (s)	Median Rest Time (s)	% Appt Examining	Avg Entry Force (N)
1	1	3:39:19	156	42.7	25	6	31%	121
	2	1:32:41	79	51.0	37	24	57%	183
2	1	1:06:14	77	70.0	20	13	43%	232
	2	1:47:47	59	32.8	30	50	33%	326
3	1	2:44:13	154	56.3	7	38	13%	141
	2	1:58:02	207	105.3	9	18	31%	242
4	1	2:28:20	47	19.1	80	46	48%	157
	2	1:05:00	100	92.3	9	22	38%	153
5	1	0:56:44	96	101.1	11	16	42%	349
	2	2:07:34	156	73.1	8	35	19%	242
6	1	3:11:40	173	54.1	10	26	18%	203
	2	2:31:12	294	116.8	5	18	25%	140
7	1	3:13:00	143	44.5	12	41	19%	157
	2	2:10:18	133	61.4	10	26	24%	199

3.6.3 Posture and physical activity

Estimated observed extreme posture (either arm inclined above 60° or 90°) for each appointment is presented in Table 3-3. To be included in the table, the observed extreme posture had to occur during the majority of exams performed and be visible on the video recording. Arm inclination of >90° was observed when a veterinarian was required to operate an overhead lever to open the cattle gate for each cow. Visit 2 for Vet 6 also included operation of an overhead pulley system, but this was not visible on the video playback and thus extreme posture status for this task could not be verified.

Table 3-3: Observed postures and exam characteristics for bovine veterinarians during farm-based reproductive exam appointments

Vet	Visit	Exam Type	Cattle Type	Cattle Agitation*	Observed Postures	Restraint Facilities	Other Activities
1	1	Manual	Dairy	1	Arm (R) >60°	Palpation rail, manual crush	n/a
	2	Manual	Dairy	1	Arm (R) >60°	Head lockers, manual crush	n/a
2	1	Manual	Dairy	2	Arms (L&R) >60°	Head lockers, hydraulic crush	Operating overhead hydraulics
	2	Manual	Dairy	1	Arm (L) >60°	Head lockers	n/a
3	1	U/S wand	Beef	2	Arm (L) >90° Arm (R) >60°	Manual head gate and crush	Opening access gate, overhead lever, cattle handling
	2	U/S wand	Beef	1	Arm (R) ~60°	Hydraulic head gate (with manual crush)	Opening access gate, cattle handling
4	1	Manual	Dairy	1	Arm (L) >60°	Tie stalls, penned	n/a
	2	U/S wand	Beef	1	Arm (L) >60°	Manual head gate and crush	Opening access gate, cattle door, cattle handling
5	1	Manual	Beef	3	Arms (L&R) >60°	Manual head gate and crush	Opening access gate, handling fence post
	2	Manual	Beef	3	Arm (L) >60°	Manual head gate and crush	Opening access gate, cattle handling
6	1	U/S wand	Beef	3	Arm (L) >60° Arm (R) >90°	Manual head gate and crush	Opening overhead lever and access gate, cattle handling
	2	U/S wand	Beef	1	Arms (L&R) >60°	Hydraulic head gate and crush	Opening access gate, overhead pulley, cattle handling
7	1	Manual	Beef	2	Arms (L&R) >60°	Manual head gate and crush	Opening cattle door, access gate, cattle handling
	2	Manual	Beef	2	Arms (L&R) >60°	Manual head gate and crush	Opening access gate, handling fence post, cattle handling

*Cattle agitation scale:
1 – majority of cattle are not subjecting the veterinarian to sudden, forceful movements
2 – approximately half of cattle subject the veterinarian to sudden, forceful movements
3 – majority of cattle subject the veterinarian to sudden, forceful movements

3.6.4 Entry force

The average estimate “rectal push” force in Newtons for each appointment can be found in Table 3-2. This force ranged from 121 N (27.2 lb) to 349 N (78.5 lb), though only two of fourteen average estimates were above 300 N.

3.6.5 Workplace design/organization

The summary of workplace factors and other potentially hazardous activities not directly related to reproductive exams can be seen in Table 3-3. Most (78%) beef exams were conducted in manually operated crushes with a head gate (Figure 3-2), while the majority of dairy exams (60%) were conducted with the cows in head lockers (Figure 3-3). Dairy cows at one operation were examined along a “palpation rail”, where they were squeezed together such that they could not move around freely while being palpated. Most dairy operations also had a palpation cage similar to the crush chute and head gate, which was occasionally used for cows with extra needs or when numbers were not sufficient to bring them to the rail or head lockers. At another dairy operation cows were in “tie stalls”, where they were tied to a stall and could otherwise move around freely. A group of dairy heifers was also palpated in a pen, which involved herding the heifer into the corner of a pen so it could not escape while being examined. Overall, dairy cattle were less frequently agitated than beef; half of all appointments saw veterinarians being regularly subjected to unpredictable forceful movements from the cattle that we characterized as agitation. All veterinarians at beef appointments were observed participating in other activities, which posed potential ergonomic risks, such as operating overhead levers or pulleys and participating in cattle handling. Cattle handling generally involved physically pushing a cow’s backside or twisting the cow’s tail to encourage her to move forward.

3.7 Discussion

This is the first known published ergonomic assessment of bovine reproductive exams involving multiple veterinarians and workplaces, and it confirms anecdotal evidence that this task can expose veterinarians to a variety of ergonomic hazards, including awkward posture, repetition, and forceful exertions. It is also common for veterinarians to participate in other tasks during reproductive exam appointments that create opportunity for additional exposures to ergonomic hazards.

While our results have no direct comparison in the literature due to this being the first assessment of this task involving multiple subjects, the findings are similar to assessments performed on other workers who participate in tasks that employ the arms and shoulders. Airport baggage handling is a job with very high incidence of back and shoulder injuries, and is a job where workers are frequently exposed to awkward postures and repetitive heavy lifting[17]. However, luggage is stationary and can be ultimately controlled by the worker; cattle are less predictable. House painting is another elevated arm task that is known to have a high incidence of shoulder symptoms[18]; while painting requires much less force than is necessary to insert a probe or arm into a cow's rectum, the repetitive above-shoulder posture used by painters has been shown to put painters at risk for shoulder injuries and increased muscle fatigue[19]. A larger cross-sectional study consisting of male machinists, car mechanics, and house painters also concluded that working with arms in an extreme elevated position (>90°) was associated with significant dose-response relationships between the postures and all levels (general pain, pain with disability, and supraspinatus tendinitis) of shoulder symptoms[20].

Awkward shoulder postures in which the arm was elevated at least 60° during exams were observed for all veterinarians in the study. It is typical for a veterinarian to elevate their arm at least 60° to enter the cow, regardless if they are inserting their arm into the cow, or using an ultrasound wand. Awkward shoulder postures were also observed during secondary tasks, especially at beef appointments. Within three appointments, veterinarians assisting with overhead gate mechanism operation to allow cattle to enter the palpation cage was observed, which required the veterinarian to reach overhead (arm inclination >150°) between each exam. At all beef appointments, the veterinarian was responsible for operating the access gate to the palpation cage before each exam; the design of the latching mechanism varied with some veterinarians mentioning that continual opening and closing of the gate was difficult on their lower arm and wrist.

Repetition as a risk factor is obviously present in this work, as the rate of observed exams reached or exceeded 100 exams/hour in several cases. Other studies have reported average exam numbers of 136-250 cows per day[2,6]; it is unlikely that these numbers are sustained every day of the working year, but rather that high workloads are seasonal and may involve several days of rest in between. In dairy appointments it was common for the median palpation exam time to exceed the median rest time. Repetitive secondary ergonomic hazards were also observed, as in the case described above regarding overhead lever and access gate opening. For each beef exam, at least one gate was also opened by the veterinarian, which may contribute to the overall exposure burden on the musculoskeletal system and hasten fatigue. Positive associations between repetitive work and shoulder symptoms have been found in older literature[14], but a recent systematic review of longitudinal studies did not find repetition to be a risk factor for shoulder symptoms; the review did find it to be a risk factor for elbow and forearm symptoms[15], and it has been shown that pain in the elbow or forearm can be a symptom of a shoulder injury[21].

Generally within the epidemiological literature, forceful or heavy physical work such as pushing has been consistently found to increase the risk of low back symptoms[14,15] and has some evidence of increasing risk of shoulder symptoms[15,22]. A recent narrative review of epidemiological and laboratory studies also found that forceful exertions to the upper limb have a strong association with multiple distal upper limb disorders such as carpal tunnel syndrome and epicondylitis[23]. While task force was not directly measured in the present study, the magnitude of the estimated force used to enter the cow fell within a fairly consistent range, with all but two appointments having estimates between 120-250N. Existing literature examining the effects of pushing generally involves a two-handed push, with the assumption the object being pushed is a cart or transfer device[22,24]. While one-handed push limits are not common, the Canadian Centre for Occupational Safety and Health (CCOHS) provides a guideline of 110 N as the limit for a one-handed push at shoulder height[25]. The type of forceful exertion a veterinarian uses to enter a cow's rectum with their arm or an ultrasound probe is unique to this profession and could benefit from its own biomechanical analysis. However, it should be noted a recent study from the Spine Research Institute calculated conservative limits for a two-handed push at 121 cm to be 290 N, above which is no longer considered "safe" loading on the lumbar spine. This limit was also determined assuming study participants were standing in a more neutral posture with elbows bent[24]. In our study, two veterinarians' average estimated force exceeded this limit in a non-neutral posture with one hand, and all participants exceeded the CCOHS's limit of 110 N. Surprisingly, we did not see a major difference between estimated force whether a veterinarian had been using an ultrasound wand or their arm for examinations, though it was clear that the force exerted by the cow on the veterinarian was greatly reduced when the veterinarian did not have to insert their arm into the cow.

Veterinarians performing bovine reproductive exams generally encounter all of the ergonomic hazards identified in previous studies focusing on posture and repetition, such as those on house painters and car mechanics, with the addition of often unpredictable forceful exertions; thus veterinarians performing this task can be considered to be at an elevated risk for upper limb musculoskeletal injuries.

It was not unexpected that we confirmed reproductive exams expose veterinarians to repetitive awkward postures and forceful exertions. However, we were not expecting secondary tasks such as gate opening and cattle handling to present such prominent posture and repetition hazards. These secondary tasks were much more consistently seen during beef appointments, where they are a non-routine task typically occurring once per year for the beef farms. Many farms accept having lower quality facilities due to infrequent use, but secondary tasks may be performed almost daily by veterinarians in the autumn months. Larger operations were observed to have higher quality, more automated (e.g. hydraulic) facilities which removed some of the repetitive strain on the farmer opening and closing the front gate of the squeeze and restrained the cow more effectively, though the gate mechanisms operated by the veterinarian were still manual in the two hydraulic facilities that we observed.

Farm-specific cattle handling techniques also appeared to have some effect on the agitation level of the cows, which may increase the risk of traumatic injury to the veterinarian. For example, when there was frequent use of an electric prod immediately before the cow was examined, the veterinarian was observed to be exposed to more forceful exertions due to the cow struggling against the procedure compared to operations that used manual cattle handling methods near the palpation cage. This is consistent with the research of Lucia et al., who have shown that adopting improved handling practices by eliminating dogs, electric prods, and human agitation creates a safer environment not only for the cattle but for the practitioners working on them as well[26].

There are limitations inherent in this exploratory study. We only observed seven veterinarians and appointment characteristics were extremely variable, thus statistical comparisons between veterinarians were not feasible. While we observed a wide variety of appointment scenarios, there are still other possibilities for organizational setup and workplace design that we did not see, and may provide more extreme exposures to the veterinarians; for example, standing on the fence rail of a chute and reaching down to palpate cows within the chute system, which was a relatively common setup until the last twenty years. The lack of direct measurement for posture and task measurements for force prevent us from quantifying posture and force in order to calculate biomechanical strain. Hand force matching estimate research has mostly focused on grip force[16,27], and validity findings for this methodology is mixed, varying from worker to worker [28]. Force is a variable that may need to be measured via simulation in a laboratory setting. We were also unable to measure or estimate the force exerted on the veterinarians by the movements of the cows; this may have been higher than the estimated entry forces. Despite the exploratory nature of the study and its limitations, the results can be used to prioritize prevention strategies.

In our observations, there was no clear evidence as to which aspect of reproductive exams is the main contributor to shoulder injuries in veterinarians. It is likely that a combination of all observed hazards work together to contribute to shoulder symptoms, along with potential individual psychosocial risk factors experienced by veterinarians such as stress due to long hours of rural work, and other exposures in their daily lives (e.g. farming, childcare, athletic activities). Awkward posture, repetition, and forceful exertions are inherent characteristics of bovine reproductive exams. Agitated cattle also increase the potential for acute injuries to the veterinarian. However, there are ways these can be minimized and there is an opportunity for veterinarians and cattle producers to work together to prioritize this, ideally following a "hierarchy of controls" (elimination, substitution, engineering, administrative, protective equipment) approach[29].

While elimination and substitution are often difficult controls to implement, there are a number of potential strategies to eliminate or reduce secondary exposures that could be implemented immediately, and need not be extensive or expensive. This may simply involve reorganizing the workday such that a farm hand is responsible for opening gates rather than the veterinarian, changing cattle handling tactics to minimize cattle agitation, or changing out a stiff gate latch for a less physically demanding mechanism. On a broader level, new restraint facilities would be ergonomically designed using a One Health framework[30], i.e. with the interconnection of human and animal wellbeing in mind. For example, a squeeze chute where all doors are operated via hydraulics would prevent any sudden loud noises or movements from spooking cows and restrain them using a full squeeze, which would encourage calmer animals that are easier for the veterinarian to palpate, minimizing any forceful movements that arise from an agitated cow, as well as removing the need for the veterinarian to manually open doors and gates. However, it is unrealistic to expect that small farms could perform costly hydraulic upgrades, so lower-cost strategies should be prioritized.

From the veterinarian's perspective, it may be initially feel difficult to request that farm clients reorganize the workplace such that they bring in more help, or fix unsafe handling facilities; clients may be unmotivated to make major changes for a job that only happens on their property once per year for a few hours. To address this, it will be important to emphasize that veterinarians perform this job at dozens, if not hundreds, of other operations over the course of the season. It does appear that veterinarians are sometimes put into difficult safety situations. They may arrive at a farm with inadequate facilities and/or personnel and be unwilling to potentially strain the client relationship by refusing unsafe work. Or, they may simply not want to stop a job they have already driven several hours to get to and would rather take the risk in order to “get ‘er done”, a common strategy described by rural farmers dealing with musculoskeletal pain[31]. Prioritizing safety and risk assessment techniques could be highlighted and emphasized in veterinarian training programs so that safer work practices and environments become an expectation of new veterinarians. Experienced veterinarians could also play a role in mentoring the upcoming generation on how to advocate for their personal safety and wellbeing.

Currently, it is typical for veterinary schools to train students to palpate with their non-dominant arm to minimize injury potential to their dominant arm, but this may be detrimental long-term. In order to reduce the strain on one shoulder due to the ergonomic hazards present in reproductive exams, veterinarians may consider an ambidextrous approach such that the burden does not all fall on a single limb. One veterinarian in the present study had adopted this approach and described a long career in large animal practice; this is a solution worthy of further investigation. Safe (human) patient handling programs have been shown to reduce injuries in health care facilities[32]; introducing an evidence-based patient handling program for practicing and student veterinarians may be similarly helpful.

Potential prevention strategies, whether they are technique-based or organizational, should be developed using a participatory ergonomics approach so that farmers and veterinarians may take ownership of the interventions[33]. Participatory ergonomics, which involves the workers in developing and implementing solutions, has been shown to consistently have a positive effect on reduction of MSK symptoms in workplaces[34], though in our case implementing participatory ergonomics within many independent farms and veterinary practices vs. a defined company or workplace would be a new challenge. Effective technical and organization strategies may already be in practice on a small scale. A previous survey of bovine veterinarians conducted by our team[4] asked participants if there were techniques that could alleviate physical stress during rectal exams; though this data was not published, participants reported a number of strategies, including body positioning and restraint techniques, that could be shared or investigated for wider use. New Zealand veterinarians surveyed by Scuffham et al. also suggested a variety of solutions when asked if anything could be done to prevent MSK symptoms resulting from rectal palpations[11]. Veterinarian feedback on diverse techniques could be used to begin the conversation and prioritize areas of focus for future intervention research and implementation.

Regardless of which prevention strategies are used, reduction of exposures to ergonomic hazards in large animal veterinary practice must be prioritized by the profession. The demographics of veterinary practice are changing; while the majority of bovine veterinarians in Canada today are men[4], 80% of current veterinary students in North America are women[35,36]. A number of studies have shown that women are at greater risk for development of MSK disorders than men, and this holds even when men and women perform identical tasks[37]. Thus, the incoming generation of veterinarians may be even more at risk from the existing ergonomic exposures than the current population of practitioners unless adequate steps for prevention are implemented.

3.8 Conclusions

Bovine reproductive exams, whether manual or ultrasound-assisted, expose veterinarians to repetitive awkward postures and forceful exertions that reach levels shown in previous research to be associated with MSK pain and injuries. Other tasks performed during these appointments, especially on beef farms, are sources of further exposure to ergonomic hazards. The exposures we estimated and observed ideally should be confirmed using direct measurement methods in future studies, or perhaps in lab-based task simulations. Nevertheless, a lack of direct measurements should not impede the veterinary community from getting a head start on intervention efforts. Prevention strategies should be designed in collaboration with veterinarians using a participatory ergonomics framework and should prioritize minimizing secondary exposures from tasks not directly inherent to reproductive exams.

3.9 References

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CHAPTER 4: DISCUSSION

4.1 Summary of results

The two manuscripts in this thesis provide results that are important when considered separately but together form a larger picture. Chapter 2 (Manuscript 1), a multiple logistic regression analysis of a cross-sectional survey of Western Canadian bovine veterinarians, concluded that members of this population who are shorter statured, work in larger practices, and primarily engage in mixed animal practice are more likely to self-report work-preventing upper extremity MSK symptoms. Bovine reproductive exams, a previously hypothesized cause, were not found to be a significant predictor of reporting these symptoms in the survey. Nonetheless, Chapter 3 (Manuscript 2) concluded that bovine reproductive exams are a task that exposes veterinarians to known ergonomic hazards (awkward posture, repetition, and forceful exertions), but also that veterinarians often engage in other physically strenuous tasks during these appointments that are not inherently part of reproductive exams. These secondary tasks may add to their biomechanical exposure, and in some cases may be worse than the actual exams.

4.2 Comparison to other results

4.2.1 Manuscript 1

It is difficult to conclusively compare our final model with other results, as our study design differed from the majority of others that have looked into similar phenomena. Only one other cross-sectional survey utilizing a regression analysis to investigate musculoskeletal symptoms has specifically targeted bovine veterinarians (conducted by Cattell with the American Association of Bovine Practitioners), and its variables greatly differed from ours[1] such that none of the variables in our final model (height, practice type, practice size) can be directly compared. The most comparable variable set may be Ergan et al.'s survey of Turkish veterinarians (who rarely work with small animals), which also utilized a modified version of the Standardized Nordic Questionnaire (SNQ) to measure self-reported symptoms, but its results are currently only published in a descriptive manner,[2] similar to our first study phase published by Zeng et al[3].

When we compare our results to similar studies conducted on all types of veterinarians, specifically those studies also employing a modified SNQ, the comparisons are mixed. Kozak et al.'s study from Germany did not combine the entire upper limb, and found "practice type" to be predictive of work-preventing symptoms in the elbow only[4], though the results were opposite to ours – Kozak et al. found large animal practitioners were more likely to report these symptoms than mixed or small animal veterinarians. They also found rectal palpations to be predictive of work-preventing injuries in the hand/wrist and the elbow. They did not use height as an independent variable, but found female gender to be predictive of work-preventing symptoms in the hand/wrist and yet protective of work-preventing symptoms in the elbow[4]. A comparison to Scuffham et al.'s New Zealand study, also using a modified SNQ on veterinarians[5], is fairly similar. They found that large animal veterinarians were more likely than mixed to report work-preventing MSK symptoms, and that performing large numbers of rectal palpations per year increased the likelihood of reporting work-preventing symptoms[5], but did not find a dose-response relationship. Scuffham et al. did not present their logistic regression results in terms of OR's, nor did they publish confidence intervals[5], so it is not possible to numerically compare our results with theirs.

Because our results are somewhat different than the often-cited works within this area of research, it will be interesting to see if other researchers follow our suggestions of improved study design, or try to replicate our results by surveying similar populations and using comparable variables.

4.2.2 Manuscript 2

This study was unique and as such, there are no direct works to compare it to, that is, there have been no other published ergonomic assessments on the task of bovine reproductive exams with the exception of our RULA pilot study performed on one veterinarian from the Western College of Veterinary Medicine (WCVM) (and also an Ergo-Vet team member)[6]. Manuscript 2 attempted to expand on the RULA-based posture analysis, which found that both manual and wand-assisted reproductive exams produced posture scores requiring immediate investigation and change[6]. These exams (especially when they involve manual rectal palpations) are a task that requires a worker to use their full body and potentially puts strain on the upper limb, so this assessment can be indirectly compared to other assessments on workers who perform strenuous upper body work. Studies on airport baggage handlers, house painters, and car mechanics/machinists have all found that upper body postures involving repetitions and forceful exertions, similar to those encountered during pregnancy checks, put workers at increased risk for developing upper limb MSK symptoms and injuries[7–10]. Considering that none of these jobs also have the added unpredictability of a live, often agitated cow, it is safe to conclude that bovine reproductive exams do increase veterinarians' risk of developing upper limb MSK symptoms, in line with existing evidence for other jobs that are physically demanding to the upper body.

Our finding that veterinarians are often expected to participate in other hazardous farming tasks during their pregnancy check appointments, such as animal handling and restraint facility operation, are consistent with research from the Saskatchewan Farmers Back Study. As part of this research, Bath et al. found that many farmers dealing with MSK pain often feel constrained by seasonal and geographic factors which force them to work while experiencing pain in order to get the job done within the required time frame[11]. Another study conducted among rural farmers in Saskatchewan found that while the majority of Saskatchewan farmers agreed that safety should be the highest priority on every farm, they do not always prioritize making necessary safety improvements, and generally accept as a fact that a good, actively involved farmer will be involved in an accident during their career[12]. When veterinarians are hired to perform work at a farm, they appear to be considered part of that farm's workforce and may feel pressure to adopt the safety attitudes of their employer in order to maintain a good working relationship.

4.3 Methodological considerations

This section will discuss the specific strengths and limitations of the sampling, measurement, and analysis strategies in each manuscript, as well as overall strengths and limitations.

Psychosocial risk factors such as stress, work support, and mental health have been shown to be associated with MSK symptom prevalence[13]. However they were considered to be outside the scope of this thesis project during the planning phase, mainly to prevent scope creep and ensure that the project would not become unmanageable for a masters degree. However, after analyzing project data from both manuscripts, risk factors emerged that may be best explained using a psychosocial lens. Thus psychosocial considerations are included for each manuscript.

4.3.1 Manuscript 1

4.3.1.1 Veterinarian sampling strategy

This was secondary analysis of data from the Ergo-Vet survey of the Western Canadian Association of Bovine Practitioners members. While there are likely many bovine veterinarians that are not members of this association, targeting this organization simplified the recruitment process as we were able to use the WCABP's mailing list (via their administrative staff to help keep the participants anonymous). This restricted our geographic base to British Columbia, Alberta, Saskatchewan, and Manitoba, which is where the majority of Canadian beef production occurs; thus, the majority of respondents worked primarily with beef and not dairy cattle. Because of this, there may have been a lower number of participants who perform manual reproductive exams (i.e. put their arm into the cows) than if we extended our survey population to all of Canada, where the majority of dairy farming is concentrated in Ontario and Quebec[14]. The WCABP had only 259 eligible members at the time of recruitment[3];this restricted our total survey participants to a maximum of 259. While we did have a participation rate of slightly over 50%, this was still a fairly small sample size which created potential for Type II errors in our modeling. As previously discussed by Zeng et al. in the original descriptive study of these results, the study sample can be considered representative of the whole WCABP membership list in terms of age and sex[3].

4.3.1.2 Musculoskeletal symptom measurement

A Standardized Nordic Questionnaire was used on the survey to assess the prevalence and severity of self-reported MSK symptoms in various body regions, and modified to add a third question specifically about bovine work prevention. This questionnaire included a picture of a human body with the regions labeled and asked the respondent to report any ache, pain or discomfort in the past 12 months – any trouble, trouble that prevented normal work tasks, and trouble that prevented bovine tasks specifically (see Figure 1-3 in Chapter 1). Because the majority of respondents primarily worked with beef, and the survey was conducted in the summer, most participants would not have been performing reproductive exams at the time of survey and may not have been experiencing related MSK symptoms as a result. This timing was selected to facilitate response rates, since survey participation was unlikely to be highly prioritized during the busiest season. However, respondents may have recalled their symptoms less accurately than if the survey was performed during (beef) pregnancy check season. It is also unknown as to whether the respondents were reporting mainly chronic or acute symptoms, as this was not specified in the survey questions. Survey questions that required chronic symptoms to meet "case" criteria would likely have resulted in a lower prevalence rate, but may have corresponded to a health outcome that is more uniformly understood than the "work-preventing" symptoms definition used in the present study.

Participants may have interpreted "work-preventing" differently. The second SNQ survey question asked *"Have you at any time in the last 12 months been prevented from doing your normal work ... because of the [MSK] trouble?"* This could have been interpreted as needing to take time off work, or simply working slower than normal, and was not clarified in the survey, a previously validated tool that has been used in hundreds of published studies[15,16]. There is some evidence that the participants took a stoic approach to reporting symptoms; the vast majority of survey respondents (97%) did mention various ways that MSK symptoms interfered with their work and well-being in their text responses to the survey's open-ended questions, but only a minority (26%) reported having work-preventing symptoms on the SNQ question[3]. Thus it is possible that these symptoms were underreported due to differing interpretations of the question. It is also likely that a variety of other factors besides just MSK symptoms contributed to work prevention in the participants, thus the outcome variable is not just a measure of pain severity. The biopsychosocial model of disability as described by the World Health Organization describes "disability" as not simply a medical issue, but as a complex interaction of internal and external features affecting an individual's ability to perform activities[17]. Potential psychosocial and environmental factors that may have influenced the survey results are discussed in section 4.3.1.4.

4.3.1.3 Statistical considerations

Multiple logistic regression using Hosmer, Lemeshow, and Strudivant's method for purposeful selection of covariates[18] was performed to build the final model. As mentioned, the small sample size (n=116) may have induced a Type II error in the modeling, especially since the number of participants reporting work-preventing symptoms was very low.

Sex and height were both found to be significant predictors for work-preventing upper extremity symptoms, but were collinear so only one could be included in the final model. Because height was slightly more significant and resulted in a better-fit model, it was selected, but there is potentially a case to be made that sex is a more important variable than height, as it is often found to increase the risk of MSK symptoms even when identical tasks are performed[19]. Though, height may be potentially modifiable via equipment or facility design.

Variable definition for exposure to reproductive exams proved difficult, and this may be partially why we did not see it emerge as a significant predictor. Participants were asked to provide the average number of "rectal examinations" they performed per year on beef cows/heifers, dairy cows/heifers, and (beef) bulls. They were also asked to estimate the percent of time they used ultrasound, and then further asked how much of their ultrasound use was with an extender wand. This allowed us to calculate crude estimates of how many ultrasound wand assisted exams and manual exams were performed in a year, but a simpler question (e.g. "For what percentage of pregnancy checks do you use an ultrasound extender wand?") would have likely achieved a more direct result. However, this still appears to be the first study that has attempted to distinguish between manual and wand-assisted reproductive exams; other literature on the subject refers mainly to "rectal palpations" which connotes the veterinarian is performing a manual palpation when this may actually not be the case.

4.3.1.4 Psychosocial considerations

Psychosocial risk factors were not directly queried in the survey, but there may be some proxies. Sex or gender is often a proxy for psychosocial risk factors, as Canadian women perform more hours of unpaid work (childcare, senior care, household chores, and volunteer work) than men[20]. Possibly as a result of these competing demands, a survey by Jelinski and Barth found that approximately 40% of female veterinarians in Canada do not work full time[21]. Large animal veterinary work is currently still a male-dominated field in Western Canada[21] and it has been well-established that women working in male-dominated fields may experience poorer mental health due to discrimination and a lack of sense of belonging[22]. The additional stress due to gender differences between male and female veterinarians could have been a risk factor for work-preventing symptoms, but we cannot know for sure based on the study data.

The variable “number of other veterinarians worked with” may also be a proxy for the common psychosocial risk factor of “work support” though not in the traditional sense; it would generally be expected that if a worker has a lot of support this will be protective against work-related MSK symptoms[23], however it is likely more complicated with veterinarians. In our case, veterinarians with more co-workers reported more work-preventing symptoms which could be due to their ability to take time off and recover if they are not the sole veterinarian in their practice. Thus, while “larger practice” appears to be associated with increased risk, it may actually speak to a more positive environment with greater work support.

While psychosocial risk factors or hazards were not explicitly measured in this survey, the open-text responses elicited a variety of responses describing how psychosocial issues (such as lack of sleep due to being on call), and emotional demands of being a rural veterinarian, had potentially contributed to MSK symptoms. To fully comprehend the issue of MSK symptoms within this population it may be prudent to begin to include psychosocial risk factors in the mix of variables. Kozak et al. included “personal burnout” and “quantitative demands” in their study of German veterinarians and found high ratings of both variables to be associated with MSK symptoms in all of their models[4].

4.3.1.5 Strengths and limitations

This study appears to be only the second epidemiological study looking into musculoskeletal symptoms in bovine veterinarians specifically and is an improvement in many ways over Cattell’s previous study conducted on the American Association of Bovine Practitioners. While our sample size was much smaller (116 vs. 434), we had a higher response rate (51% vs. approximately 10%)[31] and collected more data overall as our survey involved 26 questions and included the modified SNQ to ensure consistency of body region identification between respondents. Cattell also only performed simple logistic regression[1] and did not attempt a multivariable model.

Though we included 26 different questions in our survey, it is impossible to anticipate every variable that might influence the results and including too many questions may run the risk of reducing response rate. In retrospect, the way we measured the physical burden of reproductive exams could have been improved as described in section 4.3.1.3. As well, we may have asked different questions about work organization and habits, such as whether the participants worked full or part time, and whether their practice was rural or urban based.

4.3.2 Manuscript 2

4.3.2.1 Veterinarian sampling strategy

This was an exploratory study by design and we did not have any expectations of collecting enough data to perform statistical comparisons. The original goal was to include six participants and follow them on two reproductive exam visits each. We also originally only planned to include veterinarians who were performing primarily manual palpations, but soon realized there were not very many practicing veterinarians who perform solely manual beef exams and thus this was not only an unrealistic goal, but also less practical than assessing work as it is actually performed in clinical practice. In order to recruit enough participants we included veterinarians performing ultrasound wand-assisted exams, which turned out to be beneficial as the most extreme secondary ergonomic hazards occurred at appointments where the veterinarians were using ultrasound wands.

We were not particularly successful in finding participants with an open call recruitment email. Three of our seven participants were recruited this way, with the last one being recruited only after we opened up the call to the entire province of Saskatchewan. It is possible that using mostly contacts of the research team as participants could have influenced results, as veterinarians who have strong relationships with the WCVM may be more professionally engaged and thus more likely to follow best practices. However, we did not notice any major differences in safety practices or farm facilities between the two recruitment groups; best and worst practices were noted within both groups. As this was an exploratory study, our main priority was seeing as many different pregnancy checking scenarios as possible which targeted sampling helped us to achieve. Even if the specific veterinarians in this study did influence the results towards lower exposures, these results still support the need for interventions.

4.3.2.2 Repetition measurements

Video playback was used to count the number of reproductive exams and record the durations. For the majority of recorded exams this method can be considered accurate to within one second. Occasionally, the beginning or end of an exam was out of frame due to the videographer shifting their focus while changing position, a farm worker (or researcher) walking into the frame, or the positioning of the veterinarian or cow's body blocking the view. Nevertheless, these video recordings proved extremely valuable not only for measuring repetition but confirming/validating posture measurements (see section 4.3.2.3), assessing animal agitation and handling, and observing secondary ergonomic hazards (4.3.2.5).

4.3.2.3 Posture measurements

Extreme postures (arm elevated >60° and/or 90°) were determined observationally. While this was not as accurate as taking direct measurements, it is a common way to evaluate posture in field-based ergonomic studies[24]. The video recordings were watched in their entirety and an overall average extreme posture rating (either >60° or >90°) was assigned to each arm. This average posture represented repeated arm postures observed during the majority of exams.

Originally we planned to perform direct posture measurements to determine upper arm and neck postures. Participants were outfitted with NexGen Ergonomics I2M inertial sensors (see Appendix - Ergo-Vet Field Study Measurement Protocol) on their shoulders, forehead, sternum, and forearm of the non-palpation arm. Posture data was recorded during the appointment using the low power logging function.

Due to the time constraints of data collection, namely ensuring data could be collected during beef palpation season, the data from the sensors was not processed until several months after data collection was completed. Upon processing it was discovered that original assumptions made during sensor testing in the laboratory did not hold for the field data, and the resulting data could not be validated. This manifested in posture measurements inconsistent with the video observations. For example, at an appointment where the veterinarian was calculated to be 5 cm shorter on average than the rectum of the cows she was palpating, and also calculated to have spent 53 minutes with her arm physically inside the rectum of the cows, the processed data only calculated her as spending 1.8 minutes with her arm elevated above 60°, a finding which is not physically possible. This was common for the majority of the collections and thus the direct posture measurements were considered to be unusable.

Multiple attempts were made to identify the reason for the inaccurate sensor output but at this writing the cause is still unknown. It was first hypothesized that perhaps the ultrasound machines being used had somehow impacted the performance of the magnetometers but the results were similarly incoherent for collections where the veterinarian did not use ultrasound. There are no magnets that we were aware of in any of the restraint facilities. While most cows do have magnets in their stomachs to prevent any ingested metal from entering the digestive tract[25], an initial test we performed at the WCVM Rayner Dairy Barn did not show the magnetometers to be impacted by this item. It is potentially possible that having the sensors in a vehicle for sometimes up to three hours prior to the collection could have impacted the magnetometers. It is also possible that the shoulder is a difficult joint to measure using inertial sensors due to its wide range of motion, especially when combined with potential artifact sources such as heavy clothing. In previous research inclinometers have been shown to underestimate upper arm posture, especially that above 60°[26]. As well, inclinometer data has been shown to drift even over one minute recording periods[27]; in our study the shortest recording was approximately one hour and thus some drift can definitely be expected. To fully identify the issue a series of controlled tests would need to be performed, controlling for various conditions such as clothing, time, ultrasound, and vehicle use. This may be a fruitful exercise to perform so that the manufacturer/vendor and future researchers are aware of the limitations of this equipment, and can better assist with troubleshooting or strategies to overcome the limitations.

While this appears in hindsight to be a large mistake to not test the data by processing it early in the project, we had initially planned to use the HM-Analyzer processing software provided by NexGen Ergonomics, which would automatically calculate posture angles based on International Society of Biomechanics (ISB) criteria[28]. Prior to collecting field data the sensors and software were rigorously tested in a laboratory setting, albeit for a short amount of logging time. After performing field collections it was discovered that the HM-Analyzer software could not handle data sets exceeding approximately 20 minutes of time. Because the software appeared to calculate accurate results based on our lab tests, we assumed that simply repeating their calculations on the raw logging data would suffice, as it had worked in the past in the CCHSA's Farmer's Back Study[29]. However, this was the first time we had used these sensors for shoulder measurements and our assumptions turned out to be false. While unfortunate, there was still a lot of important data collected in this study, and extreme postures can still be discussed from an observational perspective.

4.3.2.4 Force measurements

4.3.2.4.1 Estimation of entry force

For fairly obvious reasons, it was not possible to directly measure the force exerted by the veterinarian to enter a live cow. There do not appear to be any current established methods for estimating one-handed push force; the majority of force estimation protocols for the hand focus on grip force[30]. We attempted to recreate the conditions of cow entry as best as possible by having the veterinarian perform the force estimations at the average height of the cows that they had been working with that day, and also by performing the estimations immediately following the data collection in the same location as the reproductive exams. While it is possible that the veterinarians consistently over or under-estimated the force required to enter the cows, the majority of average calculated estimated forces did fall within a fairly consistent range of 120-250 N, and all but four of these averages had a standard deviation of 32 N or lower (interestingly the remainder were between 61-77 N, a fairly large gap between the two sets). According to the CCOHS (using guidelines adapted from Kodak's Ergonomic Design for People at Work[31]), if the arm is fully extended and a worker is pushing at an object above shoulder height, the maximum force should not exceed 110N[32]. Thus, even our lowest estimated force exceeds these guidelines as most exams took place at or near the veterinarians' shoulder height.

4.3.2.4.2 Cattle agitation

Cattle agitation was assessed via video playback as a "group score" for the full appointment, rather than a per-cow score. The three-point agitation scale used here was created specifically for the study, but is similar to the five-point scale (often referred to as a "chute score") that is more commonly used in cattle behaviour studies[33]. In retrospect it likely would have been more appropriate to use the established chute score rather than creating our own, however this was not an animal behaviour study and the agitation score serves more as a proxy for how much force the cow was exerting on the veterinarian, or perhaps an increased risk of traumatic injury. It may be worth considering how to measure this more directly in future studies, as it is likely this force (when cattle are highly agitated) could be the highest source of physical exposure to the veterinarian's upper limb (and likely the lower limbs and back as well).

4.3.2.5 Observation of secondary hazards

While secondary ergonomic hazard sources such as operating the restraint facility became one of our main findings in this manuscript, these tasks were not initially anticipated as something to look for. However, it became very apparent by our second or third visit that these tasks could be a major issue. We initially anticipated that the direct posture measurements would tell the story of the secondary hazards (such as a veterinarian needing to raise their arm almost 180° hundreds of times in an afternoon to open a cattle gate), but as mentioned this data was not useable. Thus, the only measurement of this was to record it observationally as "participation in secondary tasks." While unfortunate that we could not include this in the overall posture story, this finding in general is very meaningful and provides an interesting commentary on job expectations and veterinarian safety culture.

4.3.2.6 Psychosocial considerations

A negative (or nonexistent) safety culture in a workplace is known to be associated with increased unsafe behaviours in the workplace, as well as increased emotional strain on workers[34]. Bovine reproductive exams are performed on-site at a client's workplace or home, rather than the veterinarian's clinic and thus the idea of a "workplace safety culture" when performing this task is very complicated. The veterinarian is essentially a contractor within another workplace and the safety culture will vary between farms. It is easy to comprehend how this lack of a consistent workplace safety culture could contribute to emotional stress for veterinarians.

Pfeffer and Carney have shown that jobs which commodify time are more stressful for workers[34]. The type of contracted on-site work described in this study is sensitive to the notion that "time is money." At one visit where a veterinarian mentioned charging by the hour, it was very apparent that the farm workers were attempting to push cattle through the chute for palpations as fast as possible, at the obvious expense of the agitation of the cows and acute danger to the veterinarian.

4.3.2.7 Strengths and limitations

A major strength of this study is its novelty. The potential for pregnancy checks to put veterinarians at risk for musculoskeletal symptoms and injuries has been long hypothesized and studied via cross-sectional study, but a full ergonomic assessment such as this one has never been published. Highlighting modifiable "outside" factors such as restraint facility design, cattle handling, and workplace organization is extremely important, as it provides a systems-level ergonomics perspective and will allow for prevention strategies to be developed that attack the root of the problem.

Another strength is that this study involved veterinarian research partners. This ensured that the study was performed within an appropriate context for a unique profession. The veterinarians were consulted for each phase of the research design, and the study was able to be planned and recruited such that the non-veterinarian researchers were well informed about what to expect when working with veterinarians. The diverse authorship team on both manuscripts also resulted in articles that are not specifically targeted toward a single audience but can be understood by a wide variety of practitioners.

We did not focus on confirming the current hypothesized mechanism for repetitive injury to the brachial plexus and/or rotator cuff during reproductive exams, as previously described in detail by Ailsby[35,36]. This would be better investigated in a lab setting. Utilizing sensitive biomechanics equipment in a field setting for this task is not feasible; it is not possible to verify body mechanics with the resolution required for confirming potential pathology via observational methods.

Prominent limitations are the small sample size and the lack of direct biomechanical measurements. However, including more participants and posture data may have been bordering on "too much" data for an exploratory study, and our results still provide a wide variety of starting points for future researchers to continue on in this field of study and improve upon our work.

4.4 Relevance of research

The results of both studies are very relevant to both the current and future demographics of the veterinary industry. As mentioned in Chapter 2, approximately 80% of current veterinary students are female, and it has been shown that female veterinarians are more likely to work in larger urban practices with small or mixed animals[21]. The majority of current bovine veterinarians in Western Canada (WCABP membership) are male[3], thus it is foreseeable that North America may soon be facing a shortage of rural livestock veterinarians if demographic trends continue. Combined with our regression modeling results that veterinarians who are shorter statured and work in larger, mixed animal practices are more likely to report work-preventing upper extremity symptoms, it is easy to see why prevention of upper extremity MSK symptoms and injuries needs to be prioritized. In the future, bovine veterinarians in North America are likely to be physically smaller than they are now, and the veterinary sector will need to make changes to ensure the changing demographics of veterinarians are able to enjoy career sustainability, for the good of the workers and the animals they serve.

Chapter 3 builds upon the relevance of Chapter 2 and begins to identify some of the ways that bovine tasks may need to be modified so that veterinarian MSK symptoms can be potentially reduced. This was only an exploratory analysis targeting one specific physically demanding task, and we hope that other researchers and ergonomists will perform more assessments of other common tasks that may be likely contributors to MSK symptoms in bovine veterinarians. This research should prove illuminating to the body of researchers who have been investigating MSK symptoms from an epidemiological standpoint and making the assumption that pregnancy checks are the most common contributor to these symptoms; it may better inform future studies and surveys in this area if there is continuing appetite to study the phenomenon from this perspective.

4.5 Knowledge translation

Both manuscripts in this thesis will be submitted for publication in peer-reviewed journals. Manuscript 1 (Chapter 2) has been accepted for publication in the *Journal of the American Veterinary Medical Association*, and Manuscript 2 (Chapter 3) is being prepared for submission to the *International Journal of Industrial Ergonomics*.

Results from the two manuscripts have been presented at a number of national and international academic and industry-based conferences including the 20th Congress of the

International Ergonomics Association, the American Industrial Hygiene Conference and Expo, the Applied Ergonomics Conference (where it received the honour of "Creativeness in Ergonomics Student of the Year" award), the 2018 Saskatchewan Epidemiology Association annual symposium, the 2018 Canadian Association for Research on Work and Health conference, and the 10th International Scientific Conference on the Prevention of Work-Related Musculoskeletal Disorders (PREMUS). We also have an ongoing partnership with the WCABP annual conference and have presented up-to-date results on the project at this conference since early 2017.

Though it is important to have exposure in peer-reviewed journals and at a variety of conferences, the most pertinent knowledge translation for this project will likely be through lay publications and presentations. Thus far we have published several articles in the quarterly WCABP newsletter, including one in partnership with students from the School of Rehabilitation Science and the Saskatchewan Physiotherapy Association[37].

As Chapter 3 contributes to the ongoing need for improved safety culture and awareness on farms/when performing farm-based tasks, safety education should be prioritized in veterinary schools. Our veterinary colleagues at WCVM plan to begin incorporating safety and risk assessment education in regular seminars and classroom training, using our research as an example. Project team members (Dr. Trask and I) have also contributed the creation of a Veterinary Injury Prevention seminar for Merck Animal Health, which has included results from the Ergo-Vet project.

It will also be important to share these results with producers and the public who retain vet services, as veterinarians should not be solely responsible for advocating for their own safety. A starting point will be to publish articles about the results using the Saskatchewan Agriculture

Health and Safety Network, the University of Saskatchewan media relations, and possibly The Conversation Canada (www.theconversation.com), an independent source of news and views, from the academic and research community, delivered direct to the public.

4.6 Future directions

Research of MSK symptoms in veterinarians via cross-sectional design has consistently shown that veterinarians experience high rates of MSK symptoms, though this is likely not the appropriate method for determining the potential mechanisms. There is now enough evidence to try a new, more involved study design in this area if there is still a goal to investigate the association between bovine reproductive exams and MSK symptoms. A longitudinal study would be ideal, with a cohort of new graduates being followed out of veterinary school for several years and recording detailed counts of reproductive exams (manual and wand-assisted), as well as using medical diagnostic procedures to track their MSK health. However, this is not a direction the Ergo-Vet project plans to take; it is time to act.

Future research in this area should focus on hazard reduction during reproductive exams, with secondary hazards being the priority. This could take multiple directions and likely requires a systems-level approach to uncover and prevent the causes of extra exposures. This may involve research into improved cattle handling techniques, restraint facility setup and design, or safety awareness and risk assessment for both veterinarians and farmers. The Ergo-Vet survey data also includes a large set of yet-unpublished MSK symptom prevention techniques used by the participants. This data may serve as a starting point for prioritizing interventions to test in future studies.

An idea was put forth by a member of the Ergo-Vet research team regarding potentially developing a safe patient handling training program for veterinarians, similar to the types of programs widely utilized in human health care. A standard set of safe lifting/handling courses for veterinarians, developed by an interdisciplinary team of physical therapists and veterinarians, would potentially have a positive effect on reducing veterinarian injuries and should be developed. As training falls near the "less effective" end of the hierarchy of controls[38], this should not be the main prevention strategy. However, education and increased awareness may be an important step in starting conversations about other effective interventions.

The best solutions will likely be developed by the workers themselves, with input from other stakeholders such as farmers. A participatory ergonomics task force which includes veterinarians, producers, and ergonomics professionals and health care providers such as physical therapists could be an effective tool for bridging the gap between the research and practice.

4.7 Conclusion

Upper-extremity musculoskeletal symptoms affect veterinarians worldwide. In Canada, bovine veterinarians in the western provinces are especially impacted if they work in large practices, work less than 50% of the time with cattle, and are shorter-statured. The task of reproductive exams was not found to be a significant predictor of these symptoms in our research, but it remains a task that veterinarians perceive to be a major contributor to their ill-health. An ergonomic assessment of bovine reproductive exams confirmed that hazards are inherent within the task that may contribute to upper-extremity MSK symptoms, but there are also other hazards that are not directly part of the task that could contribute to the development of symptoms as much, or more, than the exams. Future research should work towards controlling for these identified risk factors and on-the-job hazards, using tailored prevention strategies developed for and by bovine veterinarians. It is imperative that we act now in order to ensure that bovine veterinary work is an attractive, sustainable career for future generations of veterinarians.

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APPENDICES

Ergo-Vet Research Survey

Ergo-Vet Field Study Measurement Protocol

Ergo-Vet Field Study Biosecurity Protocol

Ergo-Vet Field Study Measurement Form

Ergo-Vet Field Study Job Hazard Analysis Form

ID: XXXX

UNIVERSITY OF SASKATCHEWAN

Research Survey

Project Title: Musculoskeletal Symptoms and Risk Factors among Bovine Veterinarians

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PREAMBLE

This survey is designed to help us understand the musculoskeletal symptoms and work demands encountered by bovine veterinarians. This information will help to identify the nature and extent of musculoskeletal issues in this occupational group, and will also help in designing future interventions to help prevent symptoms and disorders related to bovine work.

Participation in this survey is voluntary, and you can decide not to participate at any time by closing your browser, or choose not to answer any questions you don't feel comfortable with. The Survey responses will remain anonymous.

There are no known risks to participating in this survey; however, as with any online related activity the risk of breach of confidentiality is possible. All survey responses are stored at the University of Saskatchewan. Access to the data is restricted to the survey team.

The following questions are about your musculoskeletal health and work tasks. Completion of the survey should take less than 20 minutes.

This research project has been approved on ethical grounds by the University of Saskatchewan Biomedical Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office ethics.office@usask.ca (306) 966-2975. Out of town participants may call toll free 1-888- 966-2975. If you have questions or desire further information about this study before or during participation, you can contact Dr. Catherine Trask at 306-966-5544 or Catherine.trask@usask.ca

By completing and submitting this questionnaire, your free and informed consent is implied and indicates that you understand the above conditions of participation in this study.

Please compete both sides of the page

Personal Characteristics

1) Sex

☐[1] Male
☐[2] Female

2) Which hand do you use to write?

☐[1] Right-handed
☐[2] Left-handed
☐[3] Ambidextrous

3) Age |___|___| years

4) What is your height? |___|Feet |___|___|Inches OR |___|___|___|cm

5) What is your weight? |___|___|___|Pounds OR |___|___|___|kg

Work and Work Tasks

6) How many veterinarians are in your practice?
|___|___|

7) What year did you graduate from veterinary school (or do you expect to graduate)?
|__|__|__|__|

8) How many years have you been a bovine practitioner (if a student, list 0)?
|___|___| yrs

9) How do you apportion (%) amongst the following types of practice:
   a) Dairy ______%
   b) Beef ______%
   c) Equine ______%
   d) Other large animal ______%
   e) Small animals ______%

10) What are the most strenuous physical tasks you encounter in your work with cattle?
   a) Task 1: (most difficult) ____
   b) Task 2: ____
   c) Task 3: ____

11) Indicate the average number of rectal examinations you perform per year on:
   a) Dairy cows/heifers |___|___|___|___|___|
   b) Beef cows/heifers |___|___|___|___|___|
   c) Beef bulls |___|___|___|___|___|

12) What percentage of the time do you use each hand for rectal exams?
   a) Right hand ______%
   b) Left hand ______% %

13) Please describe any specific techniques or strategies you use for rectal exams to avoid musculoskeletal pain/symptoms:

14) Please estimate the percentage of time you use hand-held ultrasound (U/S) for preg checking: ______%

15) If you use U/S, what percentage of time do you use an extension (handle extender)? ______%

16) If you use U/S, under what conditions do ultrasounds work well for this task? When would you use them? (or why would you not use them?)

17) If you use U/S, have you noticed any new or different musculoskeletal symptoms after using it?

☐[1] Yes   If so, what?
☐[2] No

18) Do you believe musculoskeletal symptoms can be alleviated through altering technique?

☐[1] Yes   Please explain why you think so:
☐[2] No
☐[3] Somewhat

Health Questions

19) In general, would you say your health is:

☐[1] Excellent
☐[2] Very Good
☐[3] Good
☐[4] Fair
☐[5] Poor

20) Have you ***ever*** had musculoskeletal trouble (ache, pain, discomfort):

☐[1] Yes
☐[2] No

21) If yes, what body part was the worst?

☐[1] Neck
☐[2] One or both shoulders
☐[3] One or both elbows
☐[4] One or both hands

☐[5] Upper back
☐[6] Lower back
☐[7] One or both hips/thighs
☐[8] One or both knees
☐[9] One or both ankles

22) If yes, how did it impact your work?

23) If you have ***ever*** had musculoskeletal trouble (ache, pain, discomfort), what types of treatment have you had? (Please mark all that apply)

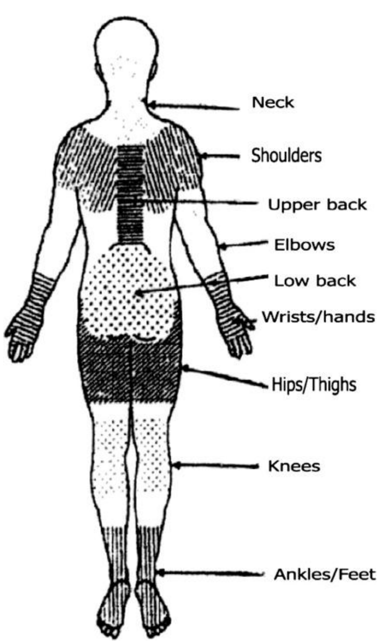
☐[1] Over the counter medication
☐[2] Prescription medication
☐[3] Surgery
☐[4] Physiotherapy
☐[5] Chiropractic
☐[6] Massage Therapy
☐[7] Acupuncture
☐[8] Exercise Therapy
☐[9] Other (please list):

24) Have you ever considered quitting bovine practice because of musculoskeletal symptoms?

☐[1] Yes
☐[2] No

Please explain why:

25) This table is about your experience in the last *12 months*



	Have you at any time in the last *12 months* had trouble (ache, pain, discomfort) in:	Have you at any time in the last *12 months* been **prevented from doing your normal work** (at home or away from home) because of the trouble?	Have you at any time in the last *12 months* been **prevented from doing bovine tasks** because of the trouble?
Neck	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐
One or both shoulders	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐
One or both elbows	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐
One or both Hands	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐
Upper Back	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐	Yes [1]☐ No [2]☐

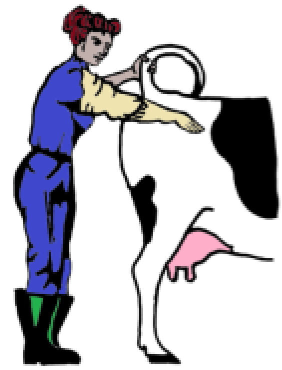
Lower Back	Yes 1☐ No 2☐	Yes 1☐ No 2☐	Yes 1☐ No 2☐
One or both hips/thighs	Yes 1☐ No 2☐	Yes 1☐ No 2☐	Yes 1☐ No 2☐
One or both knees	Yes 1☐ No 2☐	Yes 1☐ No 2☐	Yes 1☐ No 2☐
One or both ankles	Yes 1☐ No 2☐	Yes 1☐ No 2☐	Yes 1☐ No 2☐

26) Is there anything else you'd like to tell us about your musculoskeletal health or work tasks?

Thank you for your time and your contributions to this study. You have been very helpful.

Ergo-Vet Field Study:

Measurement Protocol



There are four types of measurements being done in this study:

1. Posture measurements using I2M inertial sensors (set up prior to work).
2. Vet shoulder height and “cow butt” height (take shoulder height at any time, cow butts during work).
3. Force estimates using a MicroFet II handheld dynamometer (perform after work is finished).
4. Video recording during work.

Important to mention before setting up the sensors:

As you may already know, our main goal is to find out the causes of musculoskeletal injuries in vets who perform rectal palpations, and try to prevent them. This equipment will measure your movement while you work.

- We are going to put 5 sensors on you to measure neck, trunk, and arm postures.
- We would like to tape 1 sensor to each of your your upper arms, 1 sensor to your forearm on your non-palpation arm, and strap 1 more sensor each to your chest and forehead [show the participants the sensors as you explain this].
- As you can see, the sensors are fairly light-weight and small (about the size of a watch).
- We want to learn your normal work day, so once we put on the sensors, we would like you to work as you normally would (not faster or slower).
- If at any time you find that the sensors are causing you pain or discomfort, please let us know right away, and we will take them off immediately.
- We are new to this location, so please keep an eye out for us and let us know if we are doing anything unsafe.
- We will also be “shadowing” you as you work, to take video of your work, so we will be close by if there is any problem with the sensors.
- We will do our best not to get in your way. Please don’t change your work tasks to make things easier for us. It will be up to us to figure out how to measure you.
- We will be focusing our own work, so it will be hard for us to chat, but please let us know if we are in the way, if we are changing locations, or you have any concerns, whether about the posture sensors or our safety.

OVERVIEW OF EQUIPMENT

Equipment List

- 7 × SXT IMUs (posture sensors) labeled as:
    - FH forehead (has elastic strap)
    - CH chest (has chest strap)
    - RS right shoulder
    - LS left shoulder
    - RF right forearm
    - LF left forearm
    - X extra (to be used if needed)
- 1 × SXT event button
- 12 × docking stations (organized in 2 chains of 6)
    - 2 power cables
    - 2 interface cables (MircoUSB – USB)

For this study, we will only need maximum 7 SXTs and we will not be using the access point. The next section will explain how to connect the posture sensors for our study.

Equipment Connections

1. Plug one end of the power cord into the docking stations and the other end of the power cord into the wall (Figure 1).

2. Connect the docking stations to the computer using a MicroSD – USB cable (Figure 1).

3. Dock the 7 SXTs into the 7 individual docking stations.
    a. The light on each SXT will turn dark blue (Figure 2).

Figure 1

Figure 2

EQUIPMENT CALIBRATION

Please calibrate the equipment in the laboratory, before you leave the laboratory for data collection on the farm.

- Ensure the I2M system is connected to the computer with TK Motion Manager (software), including docking stations.
- Ensure each SXT you intend to use is docked in the docking stations.

1. Open TK Motion Manager (software) using the shortcut on the desktop (***Figure 3***).

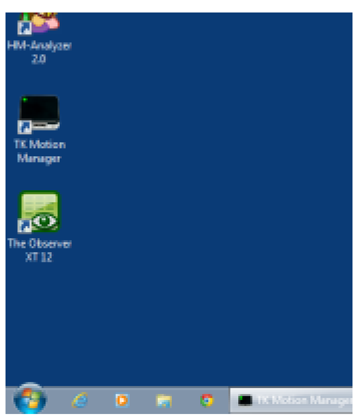


Figure 3

2. Calibrate the gyroscopes in TK Motion Manager (***Figure 4***).
   a. Select "***Calibration***", then "***Recalibrate Gyroscopes***" in the menu (upper left corner).

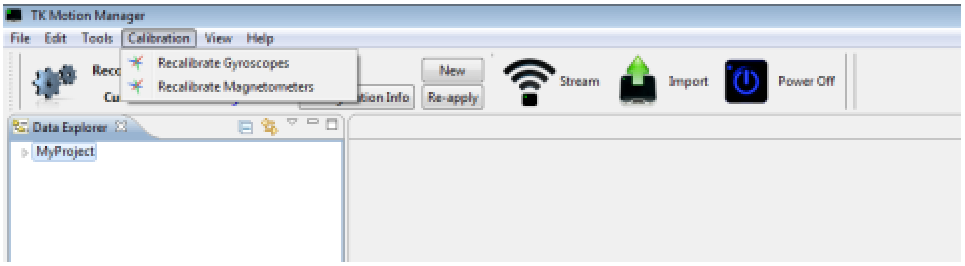


Figure 4

3. Follow the prompts in the calibration wizard. The flashing light needs to be facing away from the table during part c of Figure 5.

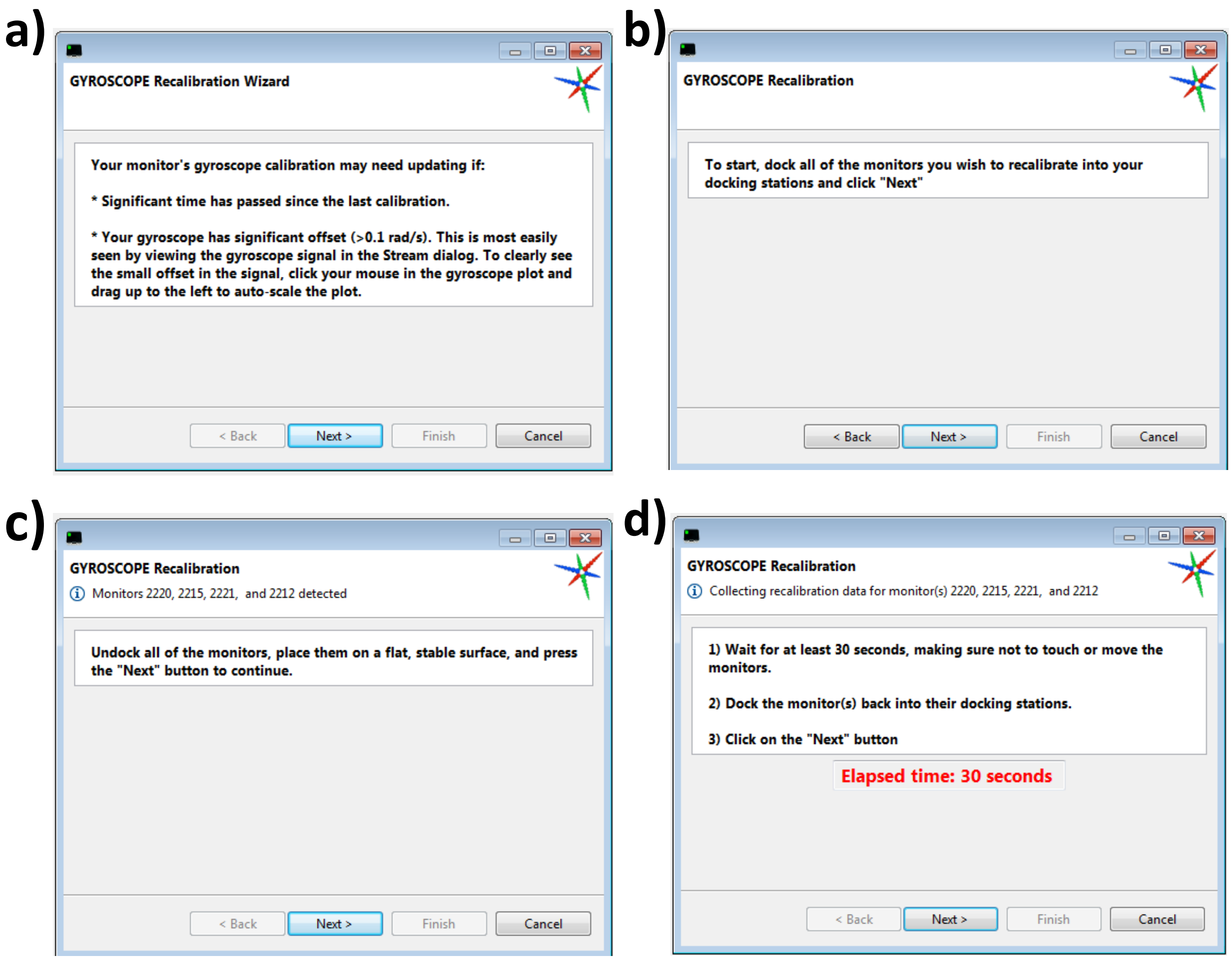


Figure 5

4. Ensure the calibration was successful (***Figure 6***). If the calibration wizard indicates that any SXT was not successfully calibrated, re-perform the entire sequence for all the SXTs.

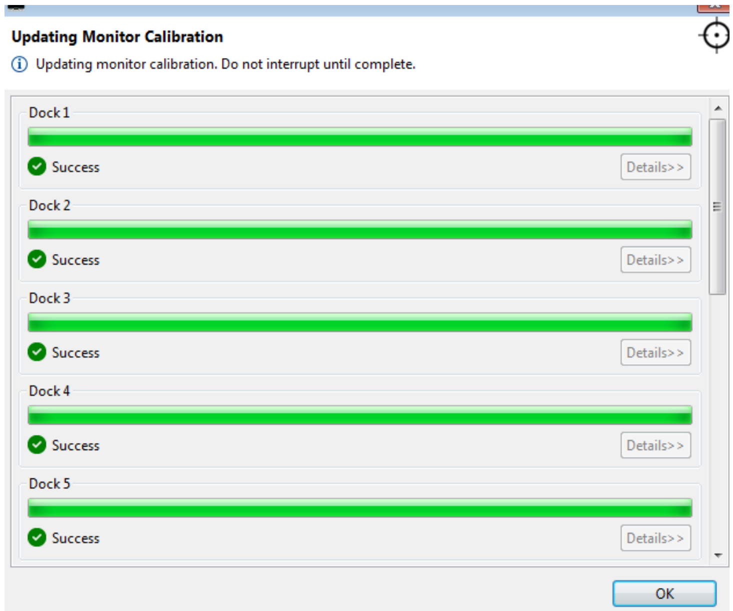


Figure 6

EQUIPMENT CONFIGURATION

Before you leave the laboratory for data collection at the barn, configure the sensors together.

1. Create a ***New Configuration*** in ***TK Motion Manager*** (Figure 7)
   a. Ensure all SXTs are docked in their stations.
   b. In the menu bar, select "***Tools***", then "***Create New Configuration***"

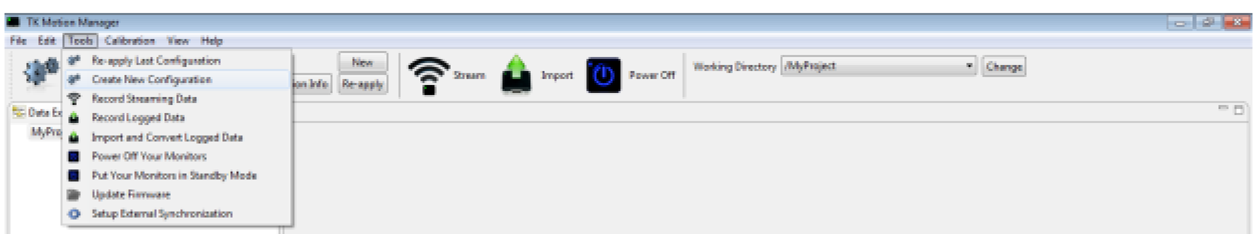


Figure 7

2. In the "***System***" tab (***Figure 8***), ensure that all the connected hardware is recognized by the computer, including all docking station(s), and monitors (***SXTs***).

3. Select the following recording options: (a) ***Recording mode – low power logging***; (b) ***wireless channel – 70***; (c) ***sampling rate – 64***.

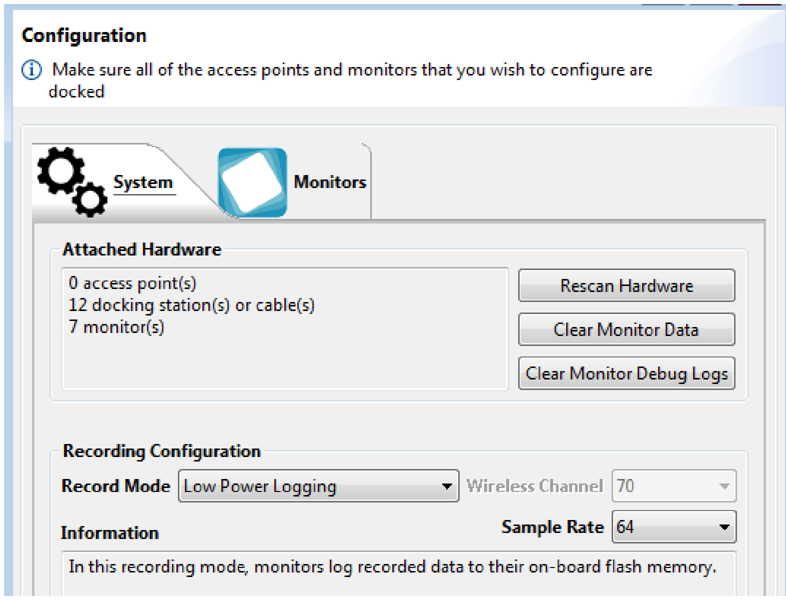


Figure 8

4. In the "***Monitors***" tab, configure each monitor (SXT) using the settings in ***Figure 9***. Briefly:

- **a.** ***Enable Accelerometers*** and ***Enable Gyroscopes*** and ***Enable Magnetometers***
- **b.** Accelerometer Range – ***6g***
- **c.** Spine Mode – ***Do Nothing***
- **d.** Battery Indicator Level – ***12s***
- **e.** Battery Charge Cutoff – ***10%***
- **f.** Button Mode – ***Mark Data***

5. Once you have specified the above configuration details for one monitor, you can select "***Copy Configuration to All Monitors***". This will copy your settings to each docked SXT.

6. Give each monitor a unique name using the "***Monitor Label***". Four our experiment, name:

- **a.** ***Monitor 2210 – Forehead***
- **b.** ***Monitor 2212 − Chest***
- **c.** ***Monitor 2223 – Extra***
- **d.** ***Monitor 2227 – L Forearm***
- **d.** ***Monitor 2220 – R Shoulder***
- **e.** ***Monitor 2224 – L Shoulder***
- ***f.*** ***Monitor 2226 – F Forearm***

Note that we will only use 5 of the 7 monitors, but we do not ask which arm people use for palpation ahead of time. The "Extra" monitor could be used on the forehead if someone cannot wear the head strap, or if one of the other monitors is malfunctioning. The actual position of each sensor on the body should be recorded on the field data collection form.

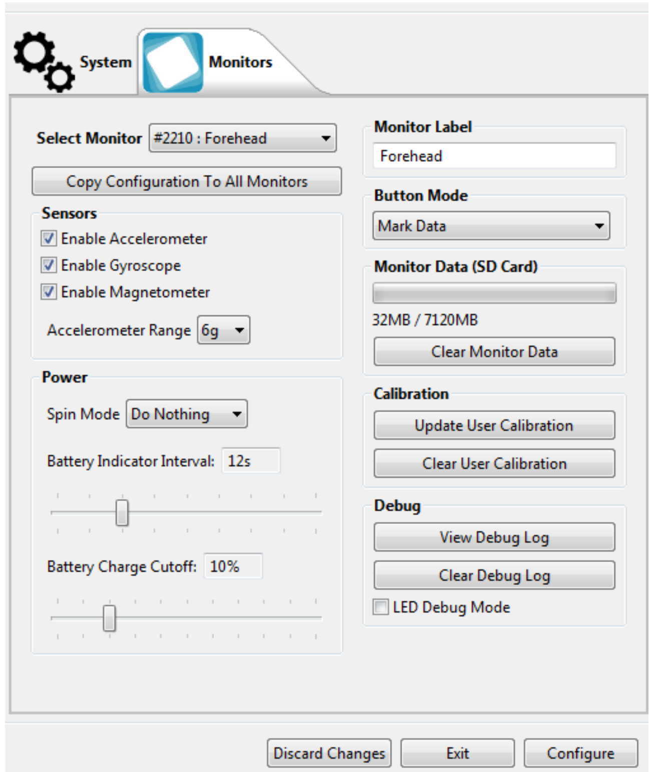


Figure 9

7. Once you have specified the configuration settings for all the monitors (steps 4-5), and labeled each monitor with a unique name (step 6), press "***Configure***" (Figure 9). You will receive a new popup widow that says the configuration was complete (Figure 10).

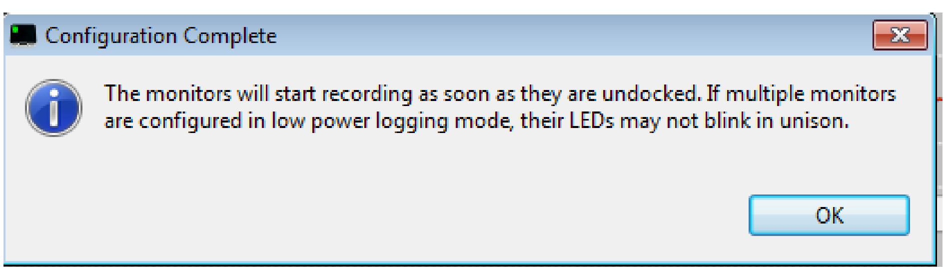


Figure 10

PRE-VISIT EQUIPMENT PREPARATION

First, make sure that all the required equipment and supplies are packed before you leave the lab for data collection at a barn. Use the ***ErgoVet Field Study Packing List*** to ensure you have everything you need.

1. Disconnect the posture sensors from the docking stations to store them in the pouch.
   a. Ensure batteries are charged. The battery is fully charged when you see 4 flashing green lights in a row. The battery is weak if you see only 1 flashing green light.
   b. Remember to pack the event button in the pouch with the posture sensors.
   c. Attach pieces of double-sided carpet tape to the arm sensors (gray side) before packing (Figure 11). Lift a corner of the tape so it is easy to detach later.
   d. Attach two pieces of double sided *wig tape* to the forehead sensor (gray side) before packing. Wig tape is hypoallergenic and can be placed directly on the skin. Lift corners of the tape so it is easy to detach later. See Figure 11.
   e. Use small piece of masking tape to cover the docking ports on each sensor except the chest (Figure 12). Put the button into the port on the chest sensor.
   f. Ahead of time, ask the vet for their t-shirt size. If it is small or medium, ensure that you have the **small** chest harness attached to the chest sensor.
      i. Remember to pack a t-shirt for the vet!

Figure 11

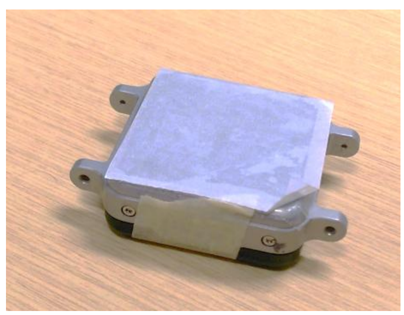


Figure 12

2. Store all the other supplies in the pouch(es).

Figure 13

Required equipment components for posture measurement. 7 posture sensors, Hypafix, leukotape, wig tape, carpet tape, scissors.

3. Before leaving the lab, cut Hypafix tape to save time at the barn (Figure 13).
   a. Cut the 2 strips of Hypafix (1 for the arm and 1 for the back) tape into lengths of 10 cm, and store them with the other supplies in the pouch.

4. Wrap the Microfet in plastic wrap (see Figure 14). Ensure it is not wrapped so tight that you cannot press the buttons. Bring along extra plastic wrap in case it tears during measurement.

Figure 14

DATA COLLECTION

When you arrive at the barn, if you have access to a table, lay out all posture sensor setup equipment as shown in the ***ErgoVet Field Study Set-up Map.***

Upper Arm Sensor Placements

Explain that you want to tape a posture sensor to both upper arms and one on the forearm of the non-palpation arm. Describe the steps as you complete them to make sure that the vet is providing continuing consent.

If there is a noticeable amount of hair on the vet's arm, ask if it is okay to lightly shave the area(s) so that the tape will stick better to their skin.

<table>
<tr><th>Explanation to the Vet</th><th>Steps for the Researcher</th></tr>
<tr><td>1. Which arm do you plan to palpate with today? (A forearm sensor will go on the non-palpation arm.)</td><td rowspan="5">• With the participant standing upright, and the arm straight at the side (vertical), landmark the acromion process of the shoulder and lateral epicondyle of the elbow.
• Note the position of the medial deltoid, along the axis between the shoulder and elbow.
• Centred over your landmarked position, place the Hypafix in line with the arm. The Hypafix will already be cut (before leaving the lab).
• The top of the Hypafix should be about 2 cm (or 1 finger-width) inferior to the acromion.
</td></tr>
<tr><td>2. Can you stand with your back and chest straight and let your arm hang by your side?</td></tr>
<tr><td>3. Can you roll up your shirt so that I can put the posture sensor on your upper arm?</td></tr>
<tr><td>4. Is it also okay if I feel your shoulder and elbow bones, so that I can make sure the sensor is in the right place, and in line with your arm?</td></tr>
<tr><td>5. Next, I am going to put a piece of square tape on your arm, and we will place the posture sensor over this tape.</td></tr>
<tr><td>6. Now, I am taping the posture sensor onto the square piece of tape already on your</td><td>• Remove the covering of the double-sided tape on the back of the posture sensor.</td></tr>
</table>

<table>
<tr>
<td>arm. This helps the sensor stick better (instead of putting it right on your skin).</td>
<td>

Affix the sensor to the Hypafix on the arm of the participant.
The center of the sensor should be placed over the belly of the medial deltoid.
Make sure the sensor is oriented so that the flashing light is closest to the top of the shoulder (facing “up”).

</td>
</tr>
<tr>
<td>
7. Now I am going to tape over the sensor to make sure that it will not move while you are working.
8. Repeat on the other arm.
</td>
<td>

Use two pieces of Leukotape (12-13 cm lengths) to further secure the sensor.
You can cut the Leuokotape at the farm, before you start setting up the posture sensors.
Ensuring that the tape adheres well to both the front and side surfaces of the recorder.


</td>
</tr>
</table>

Forearm Sensor Placement

<table>
<tr><th>Explanation to the Vet</th><th>Steps for the Researcher</th></tr>
<tr><td>1. Now I am going to attach the forearm sensor. Is it okay if we shave lightly over the area so the tape sticks better?</td><td rowspan="5">

If shaving, have the vet lay their forearm flat on the table. Lightly dry shave with the razor, and wipe off the excess hair with paper towel.
With the participant standing upright, and the arm straight at the side (vertical), landmark the ulnar and radial processes of the wrist.
The bottom of the Hypafix tape should be placed approximately three finger-widths above these processes.
Centred over your landmarked position, place the Hypafix in line with the arm. The Hypafix will already be cut (before leaving the lab).


</td></tr>
<tr><td>2. Can you stand up now with your arm hanging down naturally?</td></tr>
<tr><td>3. Is it also okay if I feel your wrist bones, so that I can make sure the sensor is in the right place, and in line with your arm?</td></tr>
<tr><td>4. Next, I am going to put a piece of square tape on your forearm, and we will place the posture sensor over this tape.</td></tr>
<tr><td>5. Now, I am taping the posture sensor onto the square piece of tape already on your arm.</td></tr>
<tr><td>6. Now I am going to tape over the sensor to make sure that it will not move while you are working.</td><td>

Remove the covering of the double-sided tape on the back of the posture sensor.
Affix the sensor to the Hypafix on the arm of the participant.
The sensor should be centred between the two processes on the Hypafix (see figure).
Make sure the sensor is oriented so the flashing light is furthest from the wrist (facing “up”).

</td></tr>
</table>

	
	• Use two pieces of Leukotape (12-13 cm lengths) to further secure the sensor. • You can cut the Leuokotape at the farm, before you start setting up the posture sensors. • Ensuring that the tape adheres well to both the front and side surfaces of the recorder. forearm info: sensor will end up underneath PPE

Forehead Sensor Placement – Using Strap

Explain that you now want to attach a posture sensor to the forehead. Ideally we use a sensor attached to a forehead strap but if it is not possible to use, we can tape one (the sensor labeled "Extra") directly to the forehead without the use of the strap.

Explanation to the Vet	***Steps for the Researcher***	
1. Explain that you want to put the sensor or motion monitor on the forehead just above the vet's eyebrows. I will first clean the skin with some alcohol to remove any oils or makeup, and then put the sensor on. There is wig tape on the sensor which should be gentle on the skin.	• Clean the forehead directly above the eyebrows with an alcohol wipe and allow to dry. • Ensure the vet is standing up straight and	

<table>
<tr><td></td><td>attach the forehead sensor just above the eyebrows using the wig tape.
If the vet is using an ultrasound headset, the sensor should still fit under this. First attach the sensor and then in the field the vet can carefully place the headset over the sensor.
Ensure the ultrasound headset is not touching or pushing on the sensor
</td></tr>
<tr><td>2. Can you please hold this in place while I secure the head strap? Is this feeling comfortable or should I loosen it a bit?</td><td>Attach the Velcro at the back of the vet's head. Adjust the looseness or tightness if necessary. If it is too uncomfortable, the sensor may need to be attached without the strap.</td></tr>
<tr><td>3. Thank you so much for your cooperation, we will remove the sensors when you will finish your work at the end of the day. If you feel uncomfortable or skin irritation please let us know we will remove the sensors.</td><td></td></tr>
</table>

Chest Sensor Placement

Explain that you now want put on a chest sensor using a chest strap (instead of tape).

Explanation to the Vet	***Steps for the Researcher***
1. Please stand straight and can you wear the harness with sensor to measure your trunk movement.	• Loosen the harness before attempting to put it on the participant. • The chest (trunk) sensor should be placed in the pocket of the trunk harness. The harness should be adjusted so that the top of the sensor is even with a horizontal line joining the medial (inner) angles of the scapulae.

2. Are you feeling comfortable or it is too tight, lose or okay?	
3. Please flex forward and bring elbows towards one another in front of the chest.	• Have the worker flex forward and bring the elbows towards one another in front of the chest to exaggerate kyphosis. If the sensor digs uncomfortably into the spinal processes, the sensor can be repositioned to the right or left of the spinal column.
4. Please take a big breath in.	• Connect all the buckles, tighten all the straps so they are snug. Have the worker take a big breath in and slide your finger under the chest strap. This should still be comfortable, ask the worker if they can breathe comfortably. Tuck in any extra straps. Do not pull the front chest strap tight – leave room for worker to move. Ensure the button is attached to the chest sensor.
	
	

Final setup of the posture sensors on the participant should look as in Figure 15.

Figure 15

Calibration

Perform the “I-pose” and “T-pose” calibrations. Before you ask the participant to hold these postures, make sure that the event marker button is attached to the chest sensor.

Explanation to the Vet	*Steps for the Researcher*
1. Next, I am going to ask you to hold 2 different postures for 5 seconds each. These postures help us analyze the data later, in our lab. The first posture is standing straight with your arms at your sides – it is called “I-pose” which is pretty self explanatory. Stand tall and face forward. Relax your arms at your side. That is great! Hold this posture please, (press button), keep holding…. Keep holding.	• Ask the vet to hold the I-pose (see the explanation to the vet) • Once you are satisfied with the posture, press the event marker button (3x) on the chest sensor. The sensor will flash blue to indicate that you pressed the event button. Record the time on the ***ErgoVet Field Measurement Tracking Form***.

Done! You can relax and move around now.	• Count 5-seconds while the vet maintains the static I-pose. 
2. We are going to do one more posture. This one is called “T-Pose” and you can probably guess why. You stand straight like the last pose, but put your arms out to the sides. Perfect, now I am going to get you to hold that posture for 5 seconds [count 5 seconds]. Okay, you can relax now and we are ready to go!	• Ask the vet to hold T-pose for 5 seconds. • Once you are satisfied with the posture, press the event marker button (3x) on the chest sensor. The sensor will flash blue to indicate that you pressed the button. Record the time on the ***ErgoVet Field Measurement Tracking Form***. • Count 5-seconds while the vet maintains the static bending posture.

Starting the Work Day and Shoulder Height

- Let the vet know that we are done setting up the posture sensors, and we would now like them to begin their day just like 'normal work day', as if we were not visiting the barn:

    1. We are done setting up the posture sensors.
    2. We would also like to film your work today. Are you okay with that?
    3. Please work as you normally do (not any faster or slower).
    4. If at any time, you find that the sensors are causing you pain or discomfort, please let us know right away, and we will either adjust them or take them off.

- Before the vet starts work, take a shoulder height measurement with the tape measure. Have them stand straight on solid ground with their feet together and measure the height of the acromion process as in Figure 16. Record this on the ***ErgoVet Field Measurement Tracking Form***.

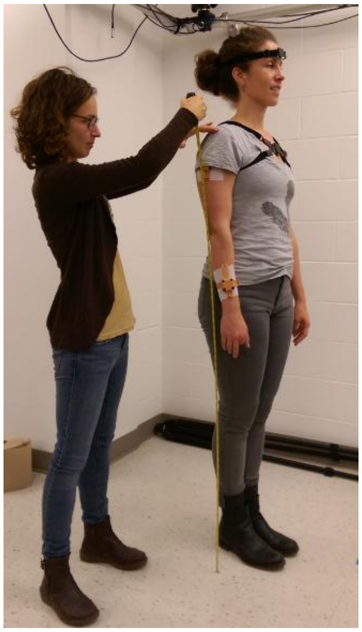


Figure 16

- Press the event marker button one more time (3x), before the worker begins their work. Once the vet starts working, begin filming at a safe distance.

During the Work – Cow Heights

- Take "cow butt" height measurements of at least 10 animals during the work day. Place the tape measure end on the ground next to the cow (make sure the tape starts on the floor at the same height the vet is standing on and measure approximately to the rectum (Figure 17). If the vet stands on a platform higher than the cow, record the *effective* height of the cow butt. You do not need to touch the cow to do this and a measurement rounded to 5 cm is appropriate. Record the heights, measurement times, and any notes about the animals on the ***ErgoVet Field Measurement Tracking Form***.
    - If you do need to touch a cow, ensure to ask the vet if it is okay to do so, as they may need to let the cow know you are there as not to spook it.
    - If you do approach animals, keep your eyes on them and don't turn your back on them. Don't under any circumstances get between a cow and calf. See the cattle handling safety materials from AHSN for more animal safety information.

Figure 17

Final Calibrations

1. When the veterinarian has finished their palpations, let them know that you are going to stop measuring posture and would like to remove the sensors. It may be possible that the vet will work longer than our data collection at the barn. If so, it is important that we discuss this, so that we can negotiate a time to take off the posture sensors. We may need to show some flexibility, so that we are not interrupting work on the farm.
2. Before removing the equipment, perform another I-pose and T-pose calibration using the same procedure as at the beginning of the measurement.

Force Estimations

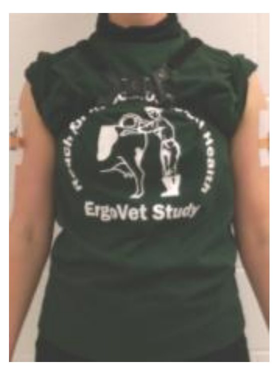
1. This can be done before or after the sensors have been removed, but it is best to do it as soon as possible after the work is completed so it is fresh in the veterinarian's mind.
2. Calculate or estimate a median cow height from the 10 measurements you took during work. Measure this height on a rail or wall and landmark it with a piece of tape.
3. Show the vet the Microfet and explain that we will be taking some force estimates of the force they used to enter the cows today. We will take five measurements at the height marked.
4. With the foam side to the marked wall or rail, have the vet push on the Microfet using as much force as they recall using during their palpations today (Figure 18).
    a. Give this consistent instruction to the vet: While holding the Microfet in your hand, pretend that mark is the cow's rectum. Press on that mark with the average amount of force you would use to enter a typical cow, and position your body as much as you can as if you are performing a palpation. We will do this 5 times, and each estimate only needs to last a couple seconds, but please try your best to recreate what you felt yourself doing during your palpations. When you finish an estimate, we will record the force recorded on the Microfet, and reset it before you start the next one.
5. Record the force on the ***ErgoVet Field Measurement Tracking Form*** and reset. Repeat this until you get 5 good measurements.

Figure 18

Removing the Sensors

1. For the arms, remove the Leukotape. Next remove the sensors.
2. Ask the participant if they want you to remove the Hypafix, or they would prefer to remove it (it often comes off quite easily in the shower).
3. If you are removing Hypafix, let the vet know that it may sting a little bit because the hair on the skin gets stuck to the tape.
4. Allow the participant to remove the chest and head sensors on their own.
5. Thank the participant, and ask if they have any questions for you.
6. Pack any equipment that was in the barn into a garbage bag to be cleaned back at the lab.

Give the participant their T-shirt!



DATA STORAGE

File Storage

We need to ensure that ***all data*** are ***downloaded*** using the established file directory, ***labelled*** using the standard convention so the files are linked to correct person, and ***backed up*** in the event of a computer failure.

- A ***unique identifier*** will be assigned ***to each person*** as they are scheduled into the study. This will be the order they were scheduled (3 digits) and the first letter of their first name. For example if the third participant was named Ellen, their participant number would be **003E**.
- ***Label the posture data using this participant ID***. Under no circumstances should the participant's name be used as an identifier.

Naming Convention

1. Each file name is coded with the following information:
    - Vet ID (4 characters)
    - Date of measurement (6 digits)
    - Sensor placement code (2 characters; either FH, CH, RS, LS, RF, LF)
    - Posture code (First I-pose "I1", First T-post "T1", Work "W", Second I-pose "I2", Second T-pose "T2")

2. An example for posture:
    - sensorID_posture_yymmdd_vetID
    - FH_I2_180922_001K

- Store separate files for each person/worker whenever possible.

Importing Data

1. When you return to the Ergonomics Laboratory, download all posture files from each sensor to the ***Networked Lenovo Desktop***.
  - **a.** Ensure all the sensors are in the docks
  - **b.** Open TK Motion Manager
  - **c.** Select Import Icon

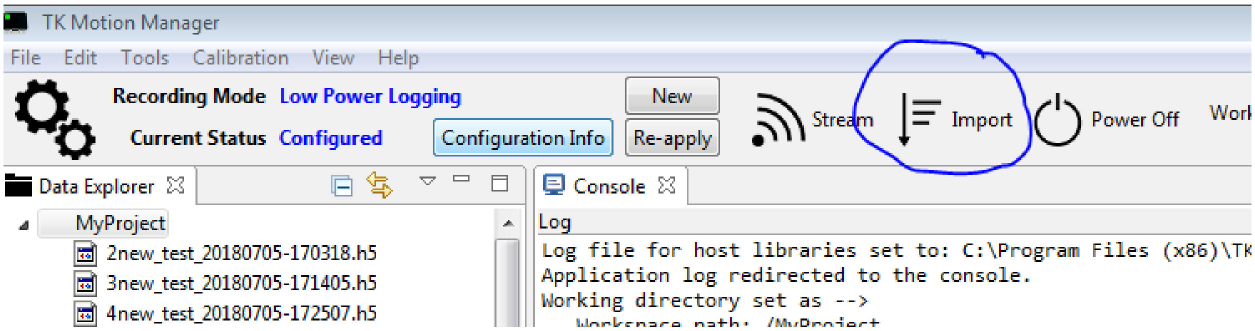


Figure 19

2. Select the data files that you wish to save from each posture sensor using the ***import and conversion wizard*** (***Figure 20***).

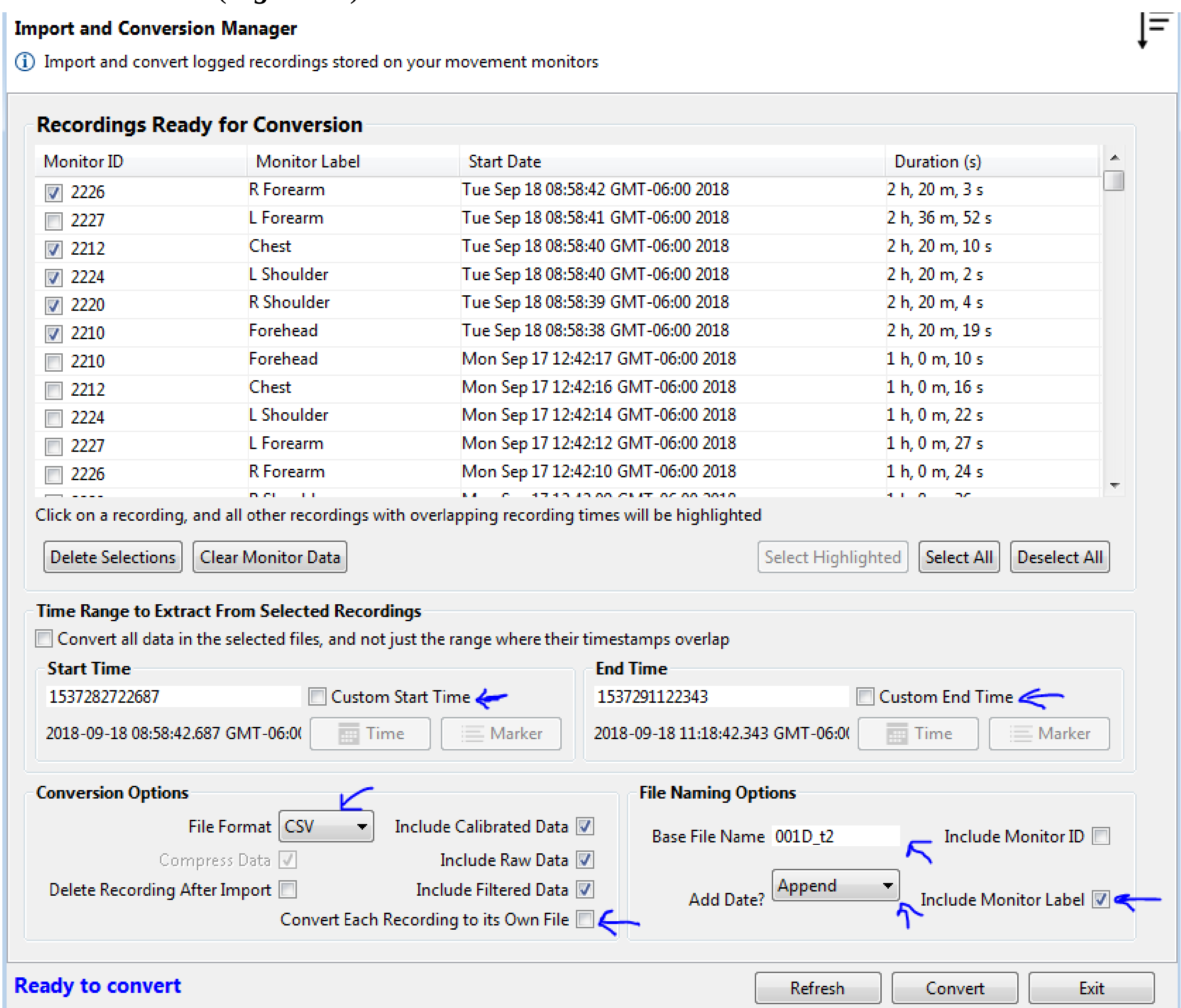


Figure 20

3. In the import and conversion window:

a. Use the event markers and/or the recorded times from the ***ErgoVet Field Measurement Tracking Form*** to select the ***start time*** and ***end time*** (Figure 20).

i. Create 1 set of files for the beginning I-pose
ii. Create 1 set of files for beginning T-pose
iii. Create 1 set of files for the full work day
iv. Create 1 set of files for end I-pose
v. Create 1 set of files for end T-pose

Note: you will have to import each set of files separately

b. ***File Format*****:** Select ***"CSV"***. Check off ***"Include Calibrated Data"*** and "***Convert Each Recording to its Own File***". Note that you have to select the file time/marker cutoffs **before** selecting "***Convert Each Recording***..."
c. ***File Name Options:*** Set the base name to be the participant number_type of work (e.g. 002F_I1).
d. ***Add Date***: Select ***"Prepend"***.
e. Check options for "***Include Monitor Label***"
f. Next, select "***Convert***"
g. 5 data files will be created (one for each sensor).
h. Repeat the steps using the appropriate start time and end time, creating a set of files for the beginning I-pose, forward bend, full workday, and end I-pose.

Notes on Start/End Times

If you have followed the button press sequence properly (Table 1), you should be able to create each file as shown in Figure 22. Ensure that you check that the button presses correspond with the recorded times.

Table 1

File	**Start**	**End**
I1	3rd button press	4th button press
T1	6th button press	15 seconds after 6th button press
Work	9th button press	10th button press
I2	15th button press	16th button press
T2	18th button press	15 seconds after 18th button press

Clock time of **'I' pose** calibration ~3 button presses~	0 9 : 5 9 (H H : M M)
Clock time of **'T' Pose** calibration ~3 button presses~	0 9 : 5 9 (H H : M M)
Clock time for work **start** ~3 button presses~	1 0 : 0 5 (H H : M M)
Work time	
Clock time for measurement **end** (last button press)	1 0 : 3 7 (H H : M M)
Clock time of **'I' pose** calibration ~3 button presses~	1 0 : 3 8 (H H : M M)
Clock time of **'T' Pose** calibration ~3 button presses~	1 0 : 3 8 (H H : M M)

Figure 21

Times of button events

Select the button event that will mark the start of the data you wish to convert

Monitor ID	Monitor Label	Start Time	Duration (ms)	
2212	Chest	2018-09-18 09:59:44.828 GMT-06:00	172	
2212	Chest	2018-09-18 09:59:45.313 GMT-06:00	171	
2212	Chest	2018-09-18 09:59:45.969 GMT-06:00	203	I
2212	Chest	2018-09-18 10:00:05.359 GMT-06:00	204	
2212	Chest	2018-09-18 10:00:05.875 GMT-06:00	203	
2212	Chest	2018-09-18 10:00:06.391 GMT-06:00	187	T
2212	Chest	2018-09-18 10:05:33.688 GMT-06:00	187	
2212	Chest	2018-09-18 10:05:34.156 GMT-06:00	188	
2212	Chest	2018-09-18 10:05:34.766 GMT-06:00	187	WS
2212	Chest	2018-09-18 10:37:35.672 GMT-06:00	234	
2212	Chest	2018-09-18 10:37:36.266 GMT-06:00	203	
2212	Chest	2018-09-18 10:37:36.859 GMT-06:00	235	WE
2212	Chest	2018-09-18 10:38:04.156 GMT-06:00	172	
2212	Chest	2018-09-18 10:38:04.641 GMT-06:00	187	
2212	Chest	2018-09-18 10:38:05.313 GMT-06:00	234	I
2212	Chest	2018-09-18 10:38:20.250 GMT-06:00	234	
2212	Chest	2018-09-18 10:38:20.938 GMT-06:00	218	
2212	Chest	2018-09-18 10:38:21.656 GMT-06:00	203	T
2212	Chest	2018-09-18 10:39:07.359 GMT-06:00	235	
2212	Chest	2018-09-18 10:39:08.063 GMT-06:00	218	
2212	Chest	2018-09-18 10:39:08.672 GMT-06:00	234	
2212	Chest	2018-09-18 10:39:09.359 GMT-06:00	282	
2212	Chest	2018-09-18 11:13:47.516 GMT-06:00	140	

Cancel Select

Figure 22 (I=I-pose, T=T-pose, WS= Work start, WE = Work end)

4. The files will automatically save in the Program Files(x86) - TK Motion Manager – Workspace - My Project folder. You will need to move them to the ErgoVet directory on Datastore and rename them for processing. Each participant should have their own folder under ErgoVet – Data – Phase II. Rename all of the files using the naming convention described at the beginning of this section and save them in their respective participant folder.

5. Ensure that for ***each vet***, there are ***25 files*** (.csv extension). There are files for 5 separate event recordings (first I-pose, first T-pose, work, second I-pose, second T-pose), and 5 posture sensors for each event (5 event recordings × 5 posture sensors = 25 files).

6. After you make sure all the correct files were correctly saved to the Datastore drive, wipe the memory of each sensor. You can do this in ***TK Motion Manager*** using the Configuration module as shown in Figure 23.

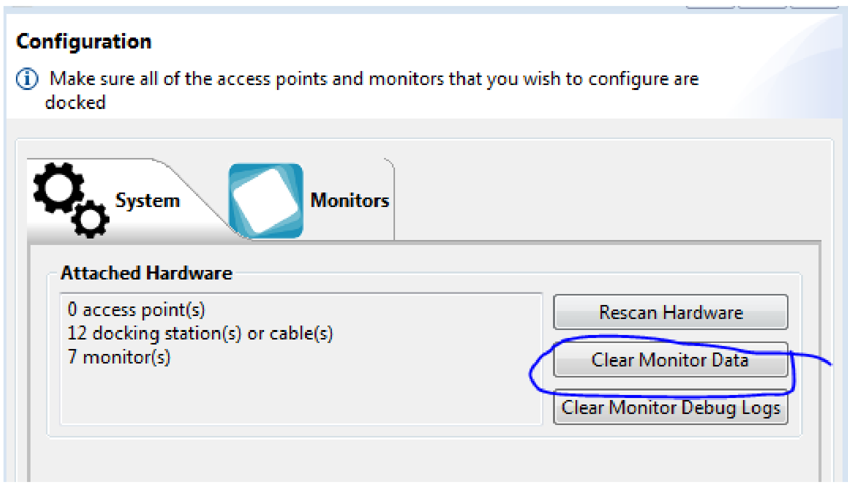
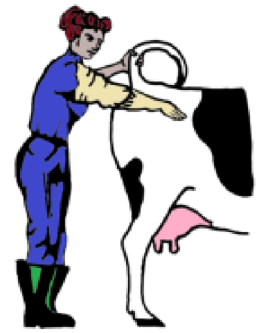


Figure 23

Ergo-Vet Field Study: Biosecurity Protocol

CCHSA CCSSMA

UNIVERSITY OF SASKATCHEWAN



Preamble

This protocol is intended to limit spread of infectious agents between farms. This protocol is considered a minimum practice for visits to farms and is not intended to preclude additional biosecurity measures which some producers may have in place (i.e. shower-in/shower-out). ***Inquire*** about producers' biosecurity procedures before arriving onsite and ***comply*** with all their procedures.

Supplies required

- □ Plastic garbage bags for dirty boots and equipment (large size)
- □ Personal clothing:
  - Coveralls
  - Boots
- □ Antiseptic wipes
- □ Antiseptic hand cleaner
- □ Rubber and nitrile gloves for cleaning
- □ Scrub brushes (plastic, wire, and putty knife)
- □ Boot bin
- □ Antiseptic cleaners (Virkon and Oxivir wipes) for boots and measurement equipment
  - MSDS for Oxivir Tb: http://www.mcoe.us/view/1757.pdf
  - MSDS for Virkon: http://www.pharmacal.com/MSDS/US/MSDSVirkonS.pdf

Definitions

Off-farm footwear	Whatever shoes you wear on the drive to the farm, and out in the community before and after the farm visit (e.g. sneakers, sandals, winter boots)
Farm boots	Boots which are CLEAN when you get to the farm, and the first steps are in the farm yard outside the van, can generally be worn the whole visit unless otherwise specified. Usually rubber boots as these are easiest to clean. These boots are considered DIRTY when you leave the farm.

Clean	Describes clothing, equipment, or a compartment/container which has been scrubbed with antiseptic and been kept contained since it was cleaned (i.e. sealed in a plastic bag, closed in a container with a lid, not open to dust etc. in the off-farm environment)
Dirty	Describes any clothing, equipment, or compartment/container which has been 'contaminated' by the outdoor environment or off-farm environment. These items remain dirty until they are scrubbed with antiseptic.

Protocol Overview

- When you get to the farm, change out of your 'dirty' off-farm footwear and leave them by your seat in the van. Change into your coveralls, and set your clean farm boots on the ground by the van to step into. Wear this around the farm.
- When you leave, change out of your boots and coveralls and place them in a plastic garbage bag along with your equipment and anything else you brought with you on the farm.
- The van, all your measurement equipment, and your boots and clothing are now considered 'dirty' and will need to be cleaned before your next visit.

Personal Preparation

- To prevent pathogen transfer between barns, allow at least **24** hours between farm visits.
- If you have been outside of Canada, you must wait 72 hours before visiting a farm.
- For the 24-hours prior to visiting a farm, the researchers shall have no contact with livestock or wildlife.
- Researchers shall wear laundered clothing to the barn and shower before their visits. Bring your farm boots in a 'clean' state.

Configuration of the Van/research vehicle

- The back compartment of the van/vehicle should have plastic garbage bags where dirty clothing and equipment will go after being used at the farm.
- Beside the front seat there should be antiseptic wipes, garbage bags, and hand cleaner.
- At the start of the trip, beside each researcher's seat there should be clean farm boots and coveralls ready to change into.

- The passenger compartment is considered 'clean'; do not enter the passenger compartment of the vehicle with dirty clothes or boots on.

Arrival Procedure

- When you get to the farm, change out of your 'dirty' off farm footwear and leave them by your seat in the van. Change into your coveralls, and set your clean farm boots on the ground by the van to step into. Wear this around the farm.

Leaving Procedure

- When you leave, change out of your coveralls and put them in a plastic garbage bag.
- Put all used equipment in a plastic garbage bag.
- Pull your coveralls off and down around your knees
- Sit in the seat and step OUT of your farm boots (leave them on the ground by the van or leave them in a plastic garbage bag).
- Take off your coveralls and put them into a plastic garbage bag. It is ok for 2 pairs of coveralls to be in the same bag. If the boots are barely soiled, the coveralls can go into the same bag as the boots (if in doubt, put them in separate bags)
- Swing your legs into the vehicle cabin and into your off-farm shoes. Do not step back onto the farm property with your off-farm shoes.
- Reach down and grab your farm boots and place them in a garbage bag, knot the bag at the top and place it in the back seat behind you. This is OK because it is a new, clean garbage bag that has not touched anything on the farm.
- The outside of the van, all your measurement equipment, and your boots and clothing are now considered 'dirty' and will need to be cleaned before your next visit.

Vehicle clean-up

- The vehicle must be cleaned at a car wash before it is considered 'clean' for the next farm visit.
- The footwells and upholstery should also be vacuumed in each spot where a researcher was sitting if there was opportunity to collect farm dust in these spots. This can be done in the parking garage at the university with the vacuum cleaner in the lab.
- It is not always possible to clean your hands thoroughly on leaving a farm. As you exit the vehicle, wipe the steering wheel, rearview mirror, gearshift, window and lock controls, and climate/radio console with antiseptic wipes. Passengers should likewise wipe their seatbelts, climate and window controls and anything else they may have touched during the drive.

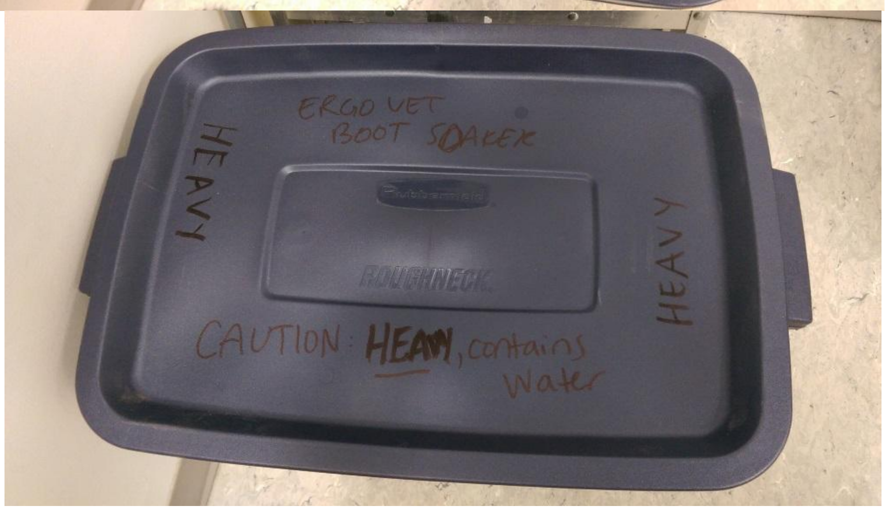
Equipment and clothing clean up

In the Ergonomics Lab:

- Once back at CCHSA, all measurement equipment should be wiped down with Oxivir Tb wipes. The monopod will be dirtier than the other equipment and should be cleaned with Virkon at the boot wash.
- All surfaces of cases, bags, and equipment that left the vehicle at the farm should be wiped down.
- Once clean and dry, equipment is now considered clean.
- Do not reuse the dirty garbage bags or you will re-contaminate the clean items. Garbage bags and any trash you brought back from the visit can go in the garbage. If you used a razor, it should be disposed of in a sharps disposal. There is one in the clinic rooms, and also in the large public washroom in the Health Sciences E-wing atrium.

At the Bootwash:

- Before starting, be sure you have read documentation and asked any questions about the chemical used:
  - MSDS for Oxivir Tb: http://www.mcoe.us/view/1757.pdf
  - MSDS for Virkon: http://www.pharmacal.com/MSDS/US/MSDSVirkonS.pdf
- The boots will need to be cleaned in the bootwash room (1241, key is in ErgoLab; alternatively 1133 in the Health Sciences loading dock custodial room).
- Place the boots in the boot bin and fill with a couple of inches of water so that the treads are completely submerged. **Cover and leave to soak** for a couple of hours, ideally overnight. It is okay to leave the bin in room 1241 overnight.



- When cleaning heavy debris off the boots, material may splash onto your face, so it is advised to wear a face shield. You may want to wear coveralls to protect your clothing as well.

- Before transferring the boots to the custodial sink, use the wire brush and putty knife to remove as much of the debris from the boots as possible in the boot bin. It is okay if this water gets very dirty. Continue cleaning the boots in the bin until they are free of debris.
    - Do not put rocks in the custodial sink – pick them out with the putty knife into the boot bin.

- When the boots are free of debris, transfer them to the custodial sink for final cleaning.
- Scrub the boots with a soft brush, rinse them, then apply Virkon cleaner. Virkon needs to sit on the boots for 5 minutes. If you are cleaning 4 boots, often the first one has sat for 5 minutes by the time you get o the last one.
- After cleaning the boots, clean the brushes and the boot bin (if applicable) with Virkon as well.
- Dump the majority of water from the boot bin down the custodial sink. If the bin is heavy and needs to be lifted, get a partner to help you lift it and/or use proper lifting technique (see image below). **Do not dump rocks into the sink**. Leave a bit of water in the bottom of the bin with the heavy debris/rocks and dump it outdoors.

Lift the bin as shown in the bottom row

(image source: Matco Moving Solutions; matco.ca)

- Once everything is cleaned, it can be brought back to the lab to dry.
- Ensure the bootwash room is left as you found it.

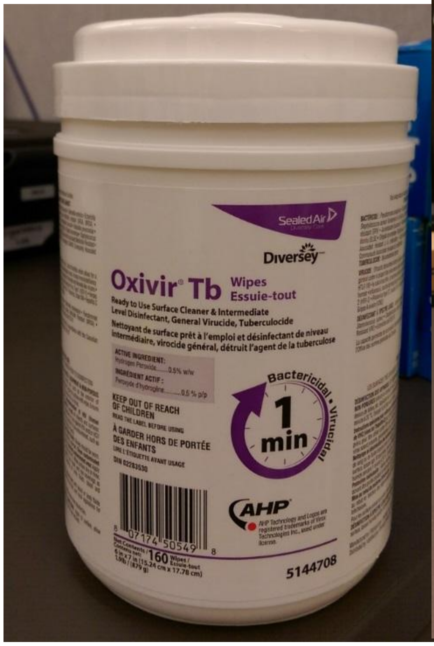
At Home:

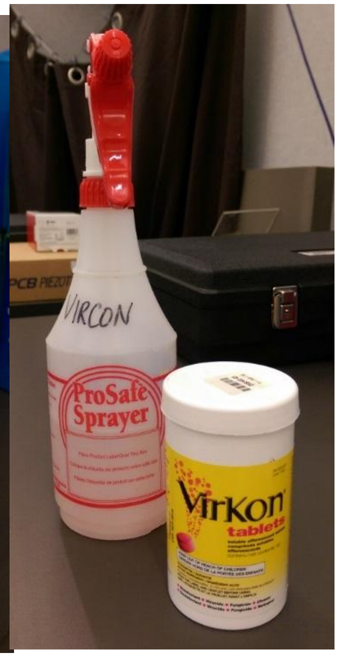
- Researchers should bring any clothing they wore to the farm to be laundered at their home, or to a public laundry.
- Coveralls (still in their plastic bag(s) can be placed in the red net laundry bag in the lab. Let Catherine know they are there and she will clean them.

About Virkon and Oxivir Tb

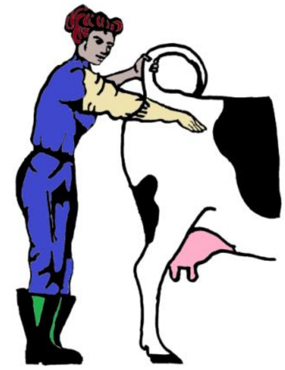
- The MSDS for Virkon is hanging on the bulletin board in the lab. Please read this before using Virkon and follow the instructions.
- Please wear gloves when using Virkon, and avoid contact with eyes, skin, and clothes.
- Virkon comes in pills that are mixed with 500mL of water in a spray bottle. If you mix a new bottle, place a label on the spray bottle that says when the Virkon will expire – it lasts for only 7 days after mixing with water. After that date, the Virkon solution should be dumped down the drain and a new batch mixed. Virkon should be stored in the lab (i.e. not brought to farms) along with paper towels, rubber gloves, and scrub brushes.
- Oxivir may cause skin peeling on sensitive skin, so wear gloves if you are unsure or have sensitive skin.

Virkon and Oxivir Cleaners





ErgoVet Field Measurement Tracking Form



Date (year, month, day) |___|___|___|___| |___|___| |___|___|	
Subject ID |___|___|___|	**Standing shoulder Ht** ___ ___ ___cm
Researcher: □ RR □ CT □ other ________________	**Palpation arm:** □ Left □ Right
Video camera set-up: □ G-green □ S-stripes SD card ID:_______	

Time Tracking		
Clock time sensors were **unplugged from doc**k	|___|___|:|___|___| H H M M	*Comments*
Clock time of **'i' pose** calibration ~3 button presses~	|___|___|:|___|___| H H M M	*Comments*
Clock time of '**T' Pose c**alibration ~3 button presses~	|___|___|:|___|___| H H M M	*Comments*
Clock time for work **start** ~3 button presses~	|___|___|:|___|___| H H M M	*Comments*
Work time		
Clock time for measurement **end** (last button press)	|___|___|:|___|___| H H M M	*Comments*
Clock time of **'i' pose** calibration ~3 button presses~	|___|___|:|___|___| H H M M	*Comments*
Clock time of '**T' Pose c**alibration ~3 button presses~	|___|___|:|___|___| H H M M	*Comments*
Force simulation measurements (see over)		
Clock time for putting sensors **back in the docks**	|___|___|:|___|___| H H M M	*Comments*

Equipment Tracking

Serial #	Written label	Position on body /notes
2210	FH forehead	□ same
2212	C chest	□ same
2220	RS right shoulder	□ same
2224	LS left shoulder	□ same
2226	RF right forearm	□ same
2227	LF left forearm	□ same

2223	X extra	Explain if used:

Workplace Description

Animal Type	Environment	Animal containment
□ Heifers □ Cows □ Other:	□ Indoor □ Outdoor □ Outdoor undercover □ Other:	□ Chute □ Squeeze / Head gate □ Rail □ Other:

Cow Height

#	Height from floor to anus	Time measured/ notes about cow
1	|___|___|___| cm	|___|___|:|___|___| H H M M
2	|___|___|___| cm	|___|___|:|___|___| H H M M
3	|___|___|___| cm	|___|___|:|___|___| H H M M
4	|___|___|___| cm	|___|___|:|___|___| H H M M
5	|___|___|___| cm	|___|___|:|___|___| H H M M
6	|___|___|___| cm	|___|___|:|___|___| H H M M
7	|___|___|___| cm	|___|___|:|___|___| H H M M
8	|___|___|___| cm	|___|___|:|___|___| H H M M
9	|___|___|___| cm	|___|___|:|___|___| H H M M
10	|___|___|___| cm	|___|___|:|___|___| H H M M

Simulated Force Measurements

** Please check that 'threshold' reads 'H' for 'high'*

#	MicroFet Height	Force in N	Comments
1	|___|___|___| cm	|___|___|___| .___|N	
2	|___|___|___| cm	|___|___|___| .___|N	
3	|___|___|___| cm	|___|___|___| .___|N	
4	|___|___|___| cm	|___|___|___| .___|N	
5	|___|___|___| cm	|___|___|___| .___|N	

Additional comments

ErgoVet Job Hazard Analysis Form

While the way we perform our measurements at each site will be similar, each farm environment will be very different. Thus it is important that the researchers familiarize themselves with this list of potential hazards, risks, and mitigation strategies prior to each farm visit.

Common Steps for all Collections

Job Step	Hazard(s)	Risk(s)	Mitigation Strategies
1. Driving to/from farm	1. Bad weather/visibility 2. Driving on country roads 3. Driving fatigue	1. Car accident 2. Poor traction, collision with other vehicles or animals 3. Accident, distracted driving	1. Do not travel in poor weather conditions. If this arises after you have started traveling, follow the CCHSA Vehicle Emergency Procedures. 2. Drive slowly (speed limit on grid roads is 80kph in ideal conditions). Both researchers pay attention for potential hazards and **point out to each other.** 3. Swap out driving between partners, eat or drink fluids as needed.
2. Arriving at farm and entering work area (also leaving/exiting)	1. Dogs and cats 2. Uneven or slippery ground, standing water	1. Unwanted contact with animals 2. Trip and fall, slip and fall, step into water hazard	1. If uncomfortable around dogs, wait a few minutes before getting out of vehicle for dog to lose interest or ask site contact for assistance. Do not approach cats if tail is down. 2. Scan the area before exiting the vehicle to be aware of potential hazards on the ground and **point out to each other.**
3. Vet briefing and setup	1. Rushing	1. Forget to discuss safety with vet or farm staff	1. Take your time and let the vet and/or farm staff know that they can feel free to tell you A) if you are getting in their way or B) in the way of any hazards.
4. Data collection	1. Cattle 2. Equipment lying around 3. Wet or icy ground	1. Unwanted contact, potential injury, exposure to bodily fluids 2. Trip and fall 3. Slip and fall 4. Hypothermia,	1. Read AHSN safe cattle handling document. Do not approach a loose cow. Stay clear of back end area to avoid fluids. If fluids get into your eyes or mouth, contact barn staff for access to eyewash or sink. 2. Scan work area for trip hazards prior to beginning collection and point them out to each other. If new ones arise during collection,

	4. Cold weather 5. Dehydration 6. Secondhand smoke, grain/barn dust 7. Dynamic fencing/gates 8. Manure storage lagoons, vats, and pumping or emptying stored manure 9. Standing around	loss of grip strength, distraction 5. Headache, distraction, fainting, hypothermia 6. Lung, eye, and throat irritation 7. Injury from getting caught in gates, pinch points, getting coveralls stuck on protrusion 8. Hydrogen sulphide poisoning (irritation, fainting, suffocation) 9. Muscle aches and pains	point them out. 3. Scan work area for slip hazards prior to beginning collection and point them out to each other. If new ones arise during collection bring to each others' attention. 4. Wear layers under coveralls and ensure head and hands are protected. Bring extra layers in vehicle to use if needed. Take turns using camera and go for warm up breaks (either just move around or warm up in vehicle). Eat a snack (in vehicle). 5. Bring water in vehicle and take a water break if needed. Ask about washroom access prior to starting work. 6. Move upwind of smoke or dust, leave area if needed, wear safety glasses if concerned 7. Scan work area for pinch/scratch hazards prior to beginning collection and point out to each other. If new ones arise during collection bring to each others' attention. 8. Stay away from stored manure, including pits, lagoons, and vats. If manure is being pumped stand upwind. Do not go into vats or barns when manure is being pumped as hydrogen sulphide can accumulate and cause poisioning. If you smell rotten eggs bring it to attention of farm hand or vet. 9. Swap out camera use and take breaks to walk around (ensure area you go to walk is safe to do so).

Site-Specific Add-Ons (if necessary)

Job Step	Hazard(s)	Risk(s)	Mitigation

We, the undersigned, have read and discussed the ErgoVet Job Hazard Analysis form on ____________________ (date) prior to performing data collection at ________________________ (location) on ________________________ (date). **We agree that if new hazards are identified during the data collection we will bring them to each others' attention immediately.** When our colleagues point out safety hazards, we thank them.

____ Researcher (Print and sign name)

____ Researcher (Print and sign name)